

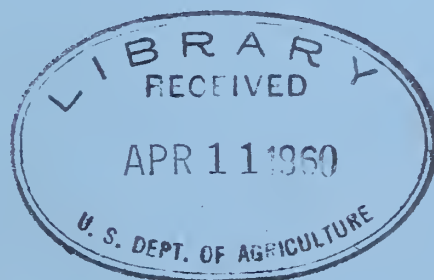
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REPORT
— OF THE —
✓ THIRD INTERNATIONAL
WHEAT RUST
CONFERENCE

HELD AT
LA OFICINA DE ESTUDIOS ESPECIALES
DE LA SECRETARIA
DE AGRICULTURA Y GANADERIA
MEXICO, D. F., MEXICO
MARCH 18 - 24, 1956.



PLANT INDUSTRY STATION
BELTSVILLE, MARYLAND
447CC-OCTOBER 1957

FOREWORD

The recent series of International Wheat Rust Conferences date back to November 17 - 18, 1950, when the first meeting was held at St. Paul, Minnesota. This meeting was called to summarize and discuss the research information that was then available on race 15B of stem rust, which during the summer of 1950 had for the first time caused serious economic losses in the wheat belt of northern United States and Canada. The interest at the first meeting was so great that a Second International Wheat Rust Conference was held in Winnipeg, Canada, from January 5 - 7, 1953. The delegates at this Conference indicated an unanimous interest in continuing this type of meeting, and a Committee was appointed to arrange for a Third International Conference during 1956.

At the invitation of the Mexican Minister of Agriculture, Sr. Don Gilberto Flores Muñoz, the Third International Wheat Rust Conference was held in Mexico City, Mexico, on March 18 - 24, 1956. The Third Conference was attended by delegates from twelve American Republics namely, Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Ecuador, Guatemala, Mexico, Peru, United States, and Uruguay. Other countries which sent delegates included Australia and Italy.

Additional English copies of this report may be obtained from The Cereal Crops Research Branch, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland, U.S.A. Spanish copies may be obtained from the Oficina de Estudios Especiales, S.A.G., Londres 40, 2º Piso, Mexico, D. F., Mexico.

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THIRD INTERNATIONAL WHEAT RUST CONFERENCE

MARCH 18-24, 1956.

MEXICO CITY, D. F.

CONFERENCE HEADQUARTERS

Oficina de Estudios Especiales, S.A.G.

Londres 40, 2nd. floor.

Tels. 46-49-15

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OFFICIAL PROGRAM

Sunday, Mar. 18

HOTEL REFORMA

3:00 - 9:00 P.M.

Registration of Delegates at Hotel Reforma

8:00 P.M.

Organizational meeting of moderators and translators to arrange procedure for schedules for sessions in Hotel Reforma in the room reserved for meetings.

Monday, Mar. 19

Auditorium Instituto Nacional de Seguro Social,
476 Paseo de la Reforma

10:00 A.M.

Introduction of Delegates at the Conference.

10:30 A.M.

Welcome to Third International
Wheat Rust Conference
ING. JESUS MERINO FERNANDEZ, Sub-Secretary of
Agriculture, Mexico,
in the name of
SR. GILBERTO FLORES MUÑOZ, Secretary of Agriculture, Mexico.

11:00 A.M.

Response in the name of the Delegates ING. JOSE VALLEGA, Director of the Plant Breeding Institute, Ministry of Agriculture, Argentina.

11:30 A.M.

Organizational meeting of Conference.

1:30 P.M.

SESSION 1. Symposium: Concepts and Methods in Breeding for Resistance to Rusts.
Moderator - L. P. Reitz
Translator - José Vallega V.

4:00 P.M. SESSION 2. Panel Discussion: Genes and sources of resistance in wheat to rusts and feasibility of utilization in breeding programs. - Leaf Rust.
Moderator and Translator: J. W. Gibler.

Tuesday, March 20 Conference Room, Oficina de Estudios Especiales, Londres 40 (2nd. floor).

8:00 A.M. SESSION 2 (Cont.) Stem Rust
Moderator - William Meyers
Translator - E. Alvarez Luna

2:30 P.M. SESSION 2 (Cont.) - Stripe Rust and Species Hybrids.
Moderator - John Schafer
Translator - Aristeo Acosta

4:30 P.M. SESSION 3. Panel Discussion: Prevalence and Potential Importance of Physiologic Races of Rust.
Moderator - W. F. Hanna
Translator - José Rodríguez Vallejo.

Wednesday, March 21 Conference Room, Oficina de Estudios Especiales, Londres 40, (2nd. floor).
(Come dressed for a field trip)

8:00 A.M. SESSION 4. Panel Discussion. Physiologic Aspects of the Rust Problem of Cereals.
Moderator - J. G. Dickson
Translator - E. Alvarez L.

10:00 A.M. SESSION 5. Panel Discussion: Taxonomy and Nomenclature of Physiologic Races of Rusts.
Moderator - William Loegering
Translator - Leonel Robles G.

12:00 M. Leave by bus from Londres 40.

1:00 P.M. The delegates are invited by MR.DUNCAN RITCHIE to have lunch at his farm.

3:00 P.M. SESSION 6. Tour of College field plots, laboratories and greenhouses at "El Horno".
Conducted by E. J. Wellhausen.

5:00 P.M.. SESSION 7. Demonstration and Discussion: Preservation of Rust Spores by Vacuum Drying
Leader: Rubén Pérez
Translator: Benjamín Ortega

Thursday, March 22 Conference Room, Oficina de Estudios Especiales, Londres 40 (2nd. floor).

9:00 A.M. SESSION 8. Panel Discussion: Epidemiology of Rusts of Cereals.
Moderator - Helen Hart
Translator - H. Cenóz

10:30 A.M. SESSION 9. Panel Discussion: Chemotherapeutic Control of Rusts.
Moderator and Translator - A. Acosta C.

11:30 A.M. SESSION 10. Misc. Papers
Moderator: T. Johnson. Translator: A. Acosta C.

2:00 P.M. SESSION 11. Panel Discussion: International Cooperative Wheat Research Projects.
Moderator and Translator - E. C. Stakman.

3:30 P.M. SESSION 12. Summary of Discussions and Future Plans.
Chairman: H. A. Rodenhiser
Translator: José Rodríguez V.

5:30 P.M. Leave for Railroad Station

6:00 P.M. Leave by Pullman for La Piedad, Guanajuato from Buenavista Station.

Friday, March 23 "La Cal Grande" Experimental Station, La Piedad, Guanajuato.

7:30 A.M. Breakfast at Hotel San Sebastián, La Piedad.

9:00 A.M. SESSION 13. Tour of "La Cal Grande" Experimental Station.
Conducted by N. E. Borlaug
The wheat research work in progress at this station includes:

- 1.- Yield test and breeding nursery which includes large numbers of lines from many different crosses.
- 2.- Backcross program of Yaqui and Gabo designed for the development of Composite varieties.
- 3.- Experiments on Cultural Practices
 - A.- Rotation
 - B.- Preparation
 - C.- Irrigation
- 4.- Soil fertility studies.

1:00 P.M.	Lunch
2:00 P.M.	Continuation of tour
4:00 P.M.	SESSION 14. Panel Discussion: Problems concerning Stripe Rust. Moderator and Translator - René Cortazar.
7:00 P.M.	Supper at Hotel San Sebastián with formal closing of Conference, conducted by ING. RICARDO ACOSTA V. Director of Agriculture.
10:00 A.M.	Delegates leave by Pullman for Mexico City.
Saturday, March 24	
8:30 A. M.	Train arrives in Mexico City. Tours have been arranged to points of interest in and around Mexico City.

ACCOMPLISHMENTS OF THE PEDIGREE AND BACKCROSS METHODS IN WHEAT BREEDING

R. F. Peterson

In December, 1955, a circular was sent to various wheat breeding institutions in North America, South America and Australia, and to a few other institutions requesting information on the use that had been made of the backcross method in wheat breeding. This was not a detailed questionnaire for statistical study but a request for information that would give a general picture of the use of the backcross method in comparison with the pedigree or other methods. The study was concerned mainly with the areas where resistance to stem rust and leaf rust is a major problem in wheat breeding. In preparing the following outline based on literature and on returns from the circular details of work at individual stations are not given, as these will in most cases be reported by individual representatives of the various stations. I wish to take this opportunity to thank all who assisted by replying to the circular.

North America

Since the beginning of this century the pedigree method has been the main method of wheat breeding and has produced most of the successful varieties which are now being used as recurrent parents in backcrossing.

In 1922 Harlan and Pope described the backcross technique of plant breeding and its advantages in cereal breeding. In the same year Dr. F. N. Briggs and his associates at the University of California began a backcross program of wheat improvement. By 1928 the backcross method had become the main method of wheat breeding at that institution, and from then until the present it has been used there almost to the exclusion of other methods.

From 1928 to the present, Dr. F. N. Briggs and his associates have improved 11 varieties of wheat by the backcross method and have released a total of 18 backcross improvements of these varieties. In the first place the Martin gene for bunt resistance was transferred to all 11 varieties. As a rule, in each backcross program, 6 to 10 backcrosses were made with rigid selection for the recurrent type in the early backcross generations. Usually F_2 and F_3 populations were grown after the first, third and sixth backcrosses in order to make backcrosses on F_3 lines having a high intensity of the character to be transferred. A number of plants of the recurrent parent were used in the final backcross, and a large number of F_3 lines were bulked for the seed increase of the improved variety.

Distinct backcrossing programs were carried out to incorporate other valuable genes in the more important of the 11 varieties. When any one backcross program was completed, the improved variety was used as a recurrent parent, and in this way several improvements were combined in a well-known commercially accepted variety. Thus one of the improved

stocks of Baart wheat has bunt resistance from Martin, stem rust resistance from Hope, and short straw and earliness from Ramona. Other characters successfully transferred to some of the varieties were stem rust resistance from Agropyron and from a Kenya variety, bunt resistance from Oro and Turkey, Hessian fly resistance, awn types and different kernel colors.

The work of Dr. Briggs and his associates has been a model for everyone using the backcross method. It has demonstrated that disease resistance can be added to adapted varieties entirely by the backcross method and that quantitative characters can be handled by this method.

In the 1920's only a few wheat breeding institutions in North America were using the backcrossing method in wheat. In the thirties there was only a moderate increase in its use. At Winnipeg, for example, H-44 was used as a donor of resistance to stem rust, leaf rust and the smuts, and Marquis was used as the recurrent parent. Rust resistant varieties with the Marquis yield and quality were developed, but were not released since Thatcher and Regent (and later Redman) outyielded them.

During the forties, when new races of stem and leaf rust were being discovered, and increasing number of wheat breeders made use of the backcross method to transfer rust resistance to adapted varieties. A considerable number of wheat breeders adopted backcrossing for the first time, and some who had used it as a secondary method now adopted it as their main method. However, most of them did not use the full backcross technique to reconstitute the recurrent parent, but used only one, two or three backcrosses so as to retain the benefits of transgressive segregation for agronomic characters such as yield and adaptation. This was a sort of compromise between the ordinary pedigree method and the full backcross method. Backcross programs under way during this period led to the development of Newthatch spring wheat and Minter winter wheat at the University of Minnesota, and Selkirk spring wheat with 15B resistance at Winnipeg. The durum varieties Carleton, Stewart, Venum, Langdon and Yuma were developed as backcross varieties at Langdon, North Dakota. The club wheats Elgin 19, Elmar and Omar were developed at Pullman, Washington. Omar derives its bunt resistance from the donor parents Turkey, Rio, Ridit and Martin. It has excellent bunt resistance and high yield.

The tremendous outbreak of 15B stem rust in North America in 1950 and the more recent appearance of still more virulent rust races have given a new impetus to the use of the backcross method. Judging by returns to the questionnaire the backcross method is now being used to some extent in the great majority of the larger wheat breeding programs in the United States. (In some States where wheat is a very minor crop it is not being used).

At Winnipeg and Saskatoon in Canada the backcross is now the main method. In Mexico the backcross program begun in 1953 is now probably the most extensive one in existence, and a very large number of donor parents is being used for sources of rust resistance.

AUSTRALIA

In Australia the frequent appearance of new rust races or biotypes led to the adoption in 1941 of the backcross method for adding genes for disease resistance to the best wheats. Fifty years of pedigree breeding had produced excellent varieties with high yield, drought resistance and good quality. These were valuable as recurrent parents.

The most intensive backcross program in Australia has been that of A. T. Pugsley carried out at the Waite Agricultural Research Institute in South Australia, and later at the Agricultural Research Institute at Wagga, New South Wales. Pugsley transferred a dominant gene for resistance to stem rust races 34 and 126B from the donor parent Gabo to ten Australian varieties, releasing nine new backcross varieties in 1948 and one in 1949. As a rule five successive backcrosses were made in the F_1 generation.

Some of these new varieties were then used as recurrent parents to add characters from donor parents as follows :

<u>Character</u>	<u>Donor Parent</u>
Stem rust resistance	Eureka Kenya 117A Kenya 112A Kenya Farmer PW-357-5 <u>T. dicoccoides</u> x <u>Ae. sharonensis</u>
Leaf rust resistance	Kenya C.6041 Uruguay 1064
Bunt resistance	Doubbi Orfed
Mildew resistance	Kenya C.6041

A considerable number of these backcross projects has been completed. For example, the genotype of Insignia has been reconstituted with combined resistance to stem rust from Gabo, leaf rust and mildew from Kenya C.6041 and leaf rust from Uruguay 1064.

At the University of Sidney, New South Wales, pedigree breeding is used for improved yield and agronomic characters, and the backcross method for transference of disease resistance to susceptible varieties. Many outstanding rust resistant varieties were developed by the pedigree method, only to succumb later to new races of rust. The backcross method was adopted in 1948. Gabo, Eureka, Kendee, Charter, Gular and others are used as recurrent parents. Donor parents for stem rust resistance are Celebration, Hofed, Kenya 117A, Egypt NA 965, Khapstein, Chinese x Agropyron elongatum, and (Illinois 1 x Chinese) x Triticum timopheevi. Donor parents for leaf rust resistance are Chinese, Chinese x Agropyron elongatum, Mentana 1124, Steinwedel x T. timopheevi, Exchange and Uruguay 1064.

In Queensland both the pedigree and backcross methods are in use. A backcross variety from Puora⁴ x Kenya 6041 with stem rust and mildew resistance is under increase. The combining cross (Puora⁶ x Argentine) x (Puora⁶ x Kenya 6041) has been made to combine resistances to stem rust, leaf rust and mildew.

In Western Australia both pedigree and backcross methods are used.

SOUTH AMERICA

In South America the pedigree method has long been used with both simple and complex crosses. In recent years the backcross method has been used extensively in Argentina, Chile, Brazil, Colombia and other countries. The system of using a relatively small number of backcrosses has been favored to make use of transgressive segregation.

OTHER AREAS

In Europe, Asia and Africa, where cereal rusts are in general less destructive, the backcross method of wheat breeding seems to be used considerably less than in North America, Australia, and South America. It appears that the danger of losses due to new physiologic races of rusts has been one of the main factors in inducing wheat breeders to adopt this method. In recent years an extensive backcross program in wheat has been initiated at Svalöf, Sweden.

Discussion

There appears to be general agreement that disease resistance can be added to existing wheat varieties entirely by the backcross method, and that it is possible to use this method for the transference of complex characters. However, the majority of wheat breeders prefer to retain the pedigree method for improving such characters as yield and adaptation, and to use the backcross method for characters of less complex inheritance such as disease resistance. The majority of wheat breeders appear to prefer a combination of the pedigree and backcross methods rather than either method alone.

Backcrossing probably has a place in every extensive wheat breeding program. The standard backcross method using 6 to 10 backcrosses is useful when the recurring parent is so well adapted that there is little scope for improving its general agronomic characteristics. However, in most situations this does not appear to be the case, and the pedigree system or some modification of it is needed to take advantage of transgressive segregation. The method of carrying out each backcross on a fairly large scale and growing the progeny to at least F_3 on a pedigree

basis is very useful. It is only in the simplest cases of transferring one or two dominant genes that it is safe to do all backcrossing on F_1 . As a general rule the progeny should be grown to F_3 at least, after alternate backcrosses.

It has often happened, in wheat breeding programs in different countries, that after only one or two backcrosses a strain is obtained that is distinctly superior to the recurrent parent in general performance. Then there is no need to continue with more backcrosses to reconstitute the recurrent parent.

In the winter wheat regions of the U.S.A. the development of suitable recurring parents has been retarded by the difficulty of growing more than one generation a year. However, outstanding varieties have been developed in recent years. The winter wheat breeder is now in a much better position to adopt the backcrossing method than he was ten or twenty years ago because improved varieties for use as recurring parents are available. The growing of more than one generation of winter wheat per year would be facilitated by a greater use of growth chambers where the plants could first be subjected to low temperatures and short days, and later to higher temperatures and longer days. Embryo culture is another method of speeding up the growing of winter wheat on a small scale.

Sec. 1 - 2

COMBINATION OF RESISTANCES AS A BREEDING PROCEDURE

I. A. Watson

Since 1938 varieties resulting from the program of breeding for stem and leaf rust resistance of wheat in Australia have been made available for commercial cultivation. Eureka was the first stem rust resistant variety and it inherited the gene *Kal*, present in a wheat from Kenya colony. This gave resistance to all known races of stem rust in Australia including 126 and 222. When a variant of race 126 viz. 126 Anz.^{1/} 2₁ arose in 1942 this gene was no longer effective.

In 1943 *Kal* was replaced by *Kcl* present in Charter, Kendee and Gabo. This latter gene was effective against 126 Anz. 1, the 1942 variant 126 Anz. 2 and all other races. New races e.g. 222 Anz. 3 against which the gene *Kcl* gave no protection were isolated in 1948 and they were either the

^{1/} The suffix Anz. indicates that this isolate of race 126 has been collected in the Australia-New Zealand geographical area and is differentiated from other isolates within this race by varieties found useful in that area

race 126 or 222, two very similar races.

In 1950 when the resistance of T. timopheevi in C. I. 12632 (Ill-1 x Chinese)² T. timopheevi was used another race 222 Anz 4 was isolated and at least one of the genes in C. I. 12632 is ineffective against this race. The main events in this sequence are summarized below where R = resistance and S = susceptibility of varieties to sub-races within the race 126-222 group.

Table 1.~ Reactions of varieties having different genes for resistance to stem rust from 1938 to 1954.

Race	Year	Variety and gene				
		Eureka	Charter	Eurga	C. I. 12632	Kenya 117A
		Kal	Kcl	Kal Kcl		Kbl
126 Anz. 1	1938	R	R	R	R	R
126 Anz. 2	1942	S	R	R	R	R
222 Anz. 3	1948	S	S	S	R	R
222 Anz. 4	1954	S	S	S	S	R

Since these various subraces behave very similarly on the regular differential series they are considered to be related genetically. At present they are regarded as stepwise gene mutations which have become evident as a result of the stepwise selection in the host for single genes for stem rust resistance. So far no new races have been found on varieties having the gene Kbl.

The happening in stem rust has also been found in leaf rust. Prior to the commencement of a breeding program only 2 races of rust could be isolated from the field when surveys were conducted over a 25 year period, 1920-1945. Since 1950, however, at least 16 different races or subraces have been found. The occurrence of some of these new types of rust has become evident as the result of the cultivation of varieties having been bred for resistance e.g. Fedweb (Federation x Webster), Gabo (Bobin² x Gaza) and Spica (Kamburico x Three Seas). Other new races have been found on hybrid material which has inherited only one of the genetic factors from an original resistant parent having two or more genes for resistance. The hybrid has become susceptible but the parent has remained resistant.

Since the isolation of new races can be associated with the splitting of gene combinations, this is interpreted as evidence for mutation in the organism for increased virulence. It indicates that single gene resistances are of less permanent value than resistances which are due to two or more independent genes. Hence in those areas where mutation is the chief mechanism for the occurrence of new races of rust two genes, both effective

against all races in the area, would appear better in combination.

At the University of Sydney the breeding program is designed to utilize genes in pairs. Gabo has been taken as one of the susceptible agronomically desirable varieties and several different genes for resistance are being added to it singly. It is proposed to combine these genes in pairs to broaden the genetic base on which resistance depends. In the following table the expected rust reactions of parents and derived lines having their resistance due to one or other of the genes A, B, C, and D, are shown.

Table 2.- Rust reactions of parental and derived lines of wheat to an original rust and 3 mutants from it.

Genotype		Reaction to Original rust	Reaction to a mutant rendering ineffective		
Donor parent	Derived line		Gene A	Gene B	Genes A and B
AA		R	S	R	S
BB		R	R	S	S
CC		R	R	R	R
DD		R	R	R	R
	AB	R	R	R	S
	AC	R	R	R	R
	AD	R	R	R	R
	BC	R	R	R	R
	BD	R	R	R	R
	CD	R	R	R	R

Theoretically the combinations should be more lasting in their resistance when the mutations are of the type indicated. However, no combinations have yet been tried in commercial varieties.

THE DEVELOPMENT AND USE OF COMPOSITE VARIETIES BASED UPON
THE MECHANICAL MIXING OF PHENOTYPICALLY SIMILAR LINES
DEVELOPED THROUGH BACKCROSSING.

Norman E. Borlaug.

Mexican wheat production has increased at a very rapid rate during the past ten years. Barring unforeseen climatic disturbances such as widespread late frosts the 1956 crop production will satisfy national consumption. The national production has risen from 500,000 tons in 1950 to an estimated 1,100,000 tons forecast for 1956 (1). During this period the average national yield per hectare has risen from 750 kilos in 1950 to 1250 kilos per hectare forecast for the current crop.

The development and distribution of well-adapted, high-yielding rust-resistant varieties has been the principal catalyst in bringing about this revolution in wheat production. The new varieties have been the "crop insurance policy" which was necessary to motivate the other three principal changes, which have immensely contributed each in its own way toward solving Mexico's bread problem, namely: 1) the opening of large tracts of (new) irrigated land suitable for wheat culture, principally in the States of Sonora and Sinaloa; 2) a renewed interest and substantial increase in the area cultivated to this crop in the Bajío and Valleys of the Mesa Central, due to the spectacular increase in yields per acre in these "old lands" (wheat culture was uneconomical in this region until new methods, i.e., the use of fertilizers and improved varieties, were introduced in 1950); and 3) the establishment of wheat as a "temporal crop" (non-irrigated crop during the rainy season). Previously, with rust-susceptible criollo ("native") varieties, it was impossible to cultivate wheat at this season of the year because of losses from stem rust. Although the total area cultivated during the rainy season is still small the potential is large and can be expanded as the need for greater national production develops.

Currently wheat is grown largely as an irrigated crop during the winter dry season. The varieties are all of spring habit, but are grown from fall plantings which are made from November through January depending upon elevation and latitude. The crop is grown from the California and Texas borders on the north, to the high Valleys of Chiapas near the Guatemala border on the south. It is grown from near sea level in Sonora and Sinaloa to an elevation of 3000 meters in some of the high Valleys of Central Mexico.

Ten years ago, with the exception of Sonora, wheat was grown with

(1) The 1956 production reached 1,300,000 tons with an average national yield of 1370 kilos per hectare.

primitive cultural practices. Virtually all of the land-preparation, planting and harvesting operations were done by mule or horse drawn equipment or by hand. Land leveling, an operation which is essential if high yields are to be obtained under irrigation, was virtually unknown. Currently the majority of the land preparation for wheat throughout the Republic is done by tractor-drawn equipment, leveling is a common practice, and nearly all farmers use grain drills. There was virtually no chemical fertilizer used in Mexico in 1950. By 1956 there were very few farmers who did not use fertilizer on their wheat, excepting those who are planting on "new land". Within this same period large self-propelled combiners have largely replaced hand harvesting.

The principal diseases of wheat in Mexico are the rusts: stem, stripe and leaf, in that order of importance. Stem rust is by far the most dangerous since it can and sometimes does become epidemic at all elevations where wheat is grown. The climatic conditions are such that this organism persists in the repeating (uredinial) stage the year around at elevations of 1700 meters and above. This results in a rapid increase of inoculum whenever climatic conditions become optimum for the rust pathogen and unless resistant varieties are grown this can result in destructive epidemics. Stripe rust may become epidemic at elevations of 1700 meters and above in certain years on the irrigated winter crop, and it is a limiting factor every year during "temporal" plantings at elevations of 2200 meters and above. Leaf rust is present at all elevations in both the irrigated and "temporal crops", but up to the present time it has been the least important of the three rusts. Bunt was formerly an important disease, but a seed treatment campaign, combined with the multiplication and distribution of new varieties, has practically eliminated this problem.

Research and extension programs have played very important roles in increasing national wheat production. The breeding program has developed early-maturing, high-yielding, stem-rust-resistance varieties which have replaced the old criollo varieties on more than 95% of the area. These new varieties are much better adapted to improved agricultural practices than the criollo varieties. They will withstand heavy fertilization with a minimum of lodging, and moreover have glumes which are more resistant to shattering and therefore better adapted to combine harvesting. Soils research has resulted in the development of fertilizer recommendations for each of the major soil types. Research on cultural practices has resulted in improved methods of land preparation, rates and dates of planting, and in better irrigation practices. The combined result of this research and its enthusiastic acceptance by the farmers has made Mexico self-sufficient in wheat production.

The wheat production potential is adequate for Mexico's domestic needs for the next 15 to 20 years, if diseases can be kept under control. Sinaloa for example this year has 45,000 hectares of wheat planted where there was none four years ago. During 1957 the area will increase to 100,000 hectares, and if needed, it can be increased to 200,000 hectares within the next four years. The crop is also adapted in the lower Río Bravo (Río Grande) Valley and can be grown there commercially if necessary.

The potential hazards from stem rust have increased greatly during the past five years. The increased hazards have resulted from: 1) introducing wheat culture into more moist areas, such as Sinaloa, which is more favorable to the development of stem rust epidemics than areas where the crop was formerly grown; 2) a greater concentration (intensification) of commercial wheat production in certain geographic area (i.e., Sonora and Sinaloa) which automatically contributes to the dangers from rust epidemics when climatic conditions are favorable and when varieties are susceptible, and 3) the development of a much more favorable micro-climatic for rust development within the grain fields as cultural practices have improved. Previous to the introduction of modern methods, wheat stands were sparse and plant development was very poor. Under such conditions the dew dried off the plants before 10 a.m. By contrast, wheat stands are rank and dense on farms using heavy fertilization and improved irrigation practices. Under these conditions the plants often remain wet with dew until mid-afternoon, thereby providing ideal ecological conditions for rust infection.

Despite the fact that the potential hazards from stem rust have increased greatly in the past six years, there have been no serious large scale commercial losses from rust. Even though there have been no serious losses during this period, on two occasions the crop was disconcertingly vulnerable to losses because of changes in the rust race population. The varieties Yaqui 48, Chapingo 48, Gabo, Kentana 48, and Lerma 50 were resistant to all of the prevalent stem rust races (17, 19, 38, 56 and 59) when they were released. The protection afforded against stem rust was, however, very short lived.

Stem rust race 15B, appeared in Mexico for the first time in March 1951, apparently resulting from inoculum blown in by northern air currents during the fall of 1950. It increased rapidly and became the most prevalent race on the Pacific Coastal Plain by 1952. This development made hazardous the cultivation of the varieties Yaqui 48 and Chapingo 48 (both carrying Hope type resistance), and Gabo (carrying T. turgidum type of resistance), since all three varieties were found to be very susceptible to this race. Similarly a group of closely related races 29, 48, 49 and 139 made their appearance and began to build up rapidly in Central Mexico during 1952 and 1953. This group of races proved to be highly pathogenic on the varieties Kentana 48 and Lerma 50. These two varieties carried Kenya 324 type of stem rust resistance, and therefore were resistant to race 15B.

Rapid multiplication and distribution of new varieties, combining the resistance to the old races and to 15B, and to races 29, 48, 49 and 139, was carried out during 1952, 1953 and 1954. Through this program the varieties Chapingo 52, Chapingo 53, Lerma Rojo, Gabo 54, Sinaloa 53, Mayo 54 and Yaqui 53 were widely distributed and grown and have afforded protection to the commercial wheat crop in recent years. How long this resistance will remain effective no one can predict.

Even though the rapid multiplication and distribution of new varieties with resistance to the new races of stem rust provided the

urgently needed protection from rust losses, there are many undesirable aspects associated with precipitous changes in varieties. Farmers are reluctant to rapidly shift their production from an old proven variety to an unknown new one. Their reluctance is based upon their familiarity with the old variety which permits them to exploit to the maximum its potential yielding ability. They know the best rates and dates of seeding of the old variety for their local conditions. They are familiar with the amount of fertilizer, the number and timing of irrigations which can be safely applied without unnecessary danger of lodging. When a new variety is introduced many of these considerations must again be worked out by the grower for his own local conditions before he is able to utilize a new variety in such a way as to approach its potential optimum productivity. Similarly the milling industry is often opposed to varietal changes, except when absolutely necessary, since it requires modifications in the blending of varieties going into their flours, and thereby complicated their industrial operations.

A third complication also sometimes occurs. When the appearance of new races threaten the commercial crop the breeder sometimes has no choice but to begin multiplication of a new variety which possesses the necessary resistance but may be inferior to the old varieties in one or more agronomic characteristics.

The sudden appearance of the new races of the rust organism thereby often leaves the plant breeder in a dilemma. On the one hand the growers and millers are reluctant to change varieties, and on the other hand failure to insist on such varietal changes, as soon as a suitable new variety is available, may result in severe economic losses throughout a large area.

The conventional backcross method of plant breeding comes closest to overcoming the dilemma. It provides, if properly carried out, new varieties which are phenotypically similar to the recurrent parent and therefore readily received by both farmer and miller. However, this method leaves much to be desired from the standpoint of the race population changes. Recognizing both the strong and weak points of the conventional backcross method the Oficina de Estudios Especiales in 1953 began a program to develop three composite or synthetic varieties of wheat. The three most important commercial varieties were chosen as recurrent parents for this program: Yaqui 50, with Newthatch type of stem rust resistance; Gabo, with T. turgidum resistance and Kentana 48, with Kenya 324 type of resistance. A group of more than 50 donor parents were chosen to cross with each of these commercial varieties. The donor parents were chosen on the basis of their reactions to stem rust in the International Wheat Rust Nurseries, and also on the basis of genetic and pathologic studies which had been carried out at many different institutions.

All segregating material from these crosses is handled by the backcross method. Backcrossing, whenever possible, is done on each succeeding F_1 generation. In all cases the F_1 plants are classified for resistance to one "tester race" in both the seedling and adult plant stage in order to identify the plants which are carrying the desired

resistance. Tester race 15B is ideal for classifying Yaqui 50 and Gabo composite material, whereas tester race 29 is used for Kentana 48 material. The seedling tests of the F_1 material is carried on in the greenhouse, after which the seedlings are transplanted to the field into two rows, one containing the seedling resistant plants and a second row containing the susceptible seedlings.

Adult plant reactions are obtained from hypodermic inoculations made in the field on tagged culms of each plant. Inoculations are made with the tester race on culms in the early boot stage of development to obtain this reaction.

Backcrossing is continued as long as is necessary in order to recover lines which are phenotypically similar to the recurrent parent with respect to the principal agronomic characteristics: height, maturity, type of head, type of plant, and grain texture, color, size and milling and backing characteristics. The number of backcrosses necessary to obtain phenotypically similar lines depends on the similarity or dissimilarity of the two parents. In all cases, however, we are attempting to isolate the phenotypically desirable lines from populations derived from the minimum possible number of backcrosses, in most cases the third backcross. It is felt that by following this principle as far as possible, we may be able to retain in some cases additional disease resistance factors from the donor parent which will be valuable in controlling diseases of secondary importance such as leaf, and stripe rust.

Once the best lines have been isolated from the segregating populations of each cross they are planted in rod rows with the recurrent parent used as a check variety. These advanced generation lines are first classified for maturity, height of plant, and morphological spike and plant characteristics. At the same time the lines are planted in rod rows, seedlings of the same lines are classified in the greenhouse using separately at least two or three stem rust races representing the prevalent race groups. Adult plant reactions for the same stem rust tester races are obtained on the material being grown in rod rows by employing the hypodermic inoculation technique. Only lines which are phenotypically similar to the recurrent parent and which also possess an additional factor for stem rust resistance are harvested. Such lines are subsequently placed in yield tests and at the same time classified for their resistance in both the seedling and adult stages against all of the individual races of stem rust which are present in the area. In order to carry out this phase of the operation it will be necessary to retain viable inoculum of all of the stem rust races which have been collected in a given geographic area.

Ultimately the best lines (based on a joint consideration of yield, agronomic characteristics, stem rust reaction, and rust race populations), will be used to form the composite variety. The composite variety will be made up of a minimum of 8 to 10 phenotypically similar lines that differ genotypically for stem rust resistance. The lines that are included in the formation of the composite variety at any given time (period of years), will be governed by the relative prevalence of the

different stem rust races and the type of resistance of each line. The make-up of the composite variety can be modified from time to time as dictated by the shift in the rust race population, by simply removing the line or lines that are permitting the increase of certain rust races and substituting other lines with different types of resistance. Viable seed of the best lines, or lines with each of the different types of rust resistance will be held in reserve, and can therefore be used to modify the composition of the composite variety as needed.

The effectiveness and the protection afforded by this composite variety, once it is grown on large commercial areas where the effect of the inblown inoculum produced on other types of resistance is reduced to a minimum, not only will depend upon the true resistance of the lines to the different races of the rust race population but will moreover depend in part upon the disease "escape mechanism", which functions more effectively in genotypically non-uniform populations. The increase in the amount of inoculum is delayed, especially in the first few generations, when rust begins to increase in a genotypically diversified population, and this delay theoretically will often permit even the susceptible lines in the composite variety to mature their grain before serious damage results. Under the conditions described above it is highly improbable that a line which is susceptible to one race in the rust population will be damaged severely, since it does not constitute more than 10 to 12-1/2 per cent of the composite population. This phenomenon is a principle which was used knowingly, by many early agricultural societies in both hemispheres to reduce crop losses from diseases, insects and drought. The present proposed system of developing composite varieties through a modification of the backcross system will simply remove the objections which are inherent in the use of mixture of phenotypes as was common in the varieties of early agricultural societies.

The use of composite varieties as described above will probably provide at least partial protection for the farmer whenever new races become prevalent and up until the time the varietal composition can be modified, since it is quite improbable that all genotypes of the composite will be completely susceptible to such a new race. As soon as a new race appears all of the lines of the variety and all of the lines held in reserve must be classified for their resistance to the new race. The composite variety can then be reformed with lines which will give maximum protection against the newly modified race population.

Should a "super-race" of rust appear which is capable of attacking all sources of resistance obviously this method like all others is doomed, but this seems highly improbable. If a "super-race" does not appear the proposed system provides the maximum flexibility that can be incorporated into any system of breeding of self pollinated crops. It will obviously find its greatest application in those crops where airborne epidemic diseases are of paramount importance, and where the race populations can change with fantastic rapidity and produce disastrous effects. The degree of refinement of the system will vary with the crop and the stage of evolution of the agricultural society in which it is employed. In countries such as the United States and Canada where standardization of wheat quality is a paramount consideration in the breeding

programs the method would certainly require a greater number of backcrosses to develop the lines with the required characteristics than is currently necessary under conditions in Mexico.

Sec. 1 - 4

THE USE OF INDUCED MUTATIONS IN BREEDING WHEAT
FOR RESISTANCE TO RUST.

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The development of improved disease-resistant varieties has constituted for many years a major part of cereal breeding programs in North America. Especially during the last two decades, plant breeders have been harassed by the appearance and rapid spread of new diseases or new forms of old diseases. To meet this challenge, breeders have found it necessary to expend their efforts almost solely in the transferring of new resistance genes to locally adapted varieties. At best, they have found it difficult to keep ahead of the advance of the pathogens.

With wheat rust, the picture seems almost at the stage where a new race may appear, spread rapidly and cause its damage, and then be replaced in importance by a different form before resistance can be rallied in new wheat varieties. This hasn't happened yet, but it could happen! Improved methods now applied by wheat breeders show that they have recognized this danger. It is now possible through better State and International cooperation for breeders of spring wheat to increase their desirable selections by growing two crops each year. In addition, with controlled growth rooms now more generally used, it is possible to carry on an accelerated backcrossing program that greatly reduces the time required for the transfer of desired new genes into old adapted varieties. However, when a new disease problem appears, plant breeders and plant pathologists must still search through an enormous collection of varieties and introductions to find resistance sources with which to work. This has never failed to produce results - but it does take time when time may be very expensive to the farmer.

If it were possible for the plant breeder to induce the desired resistance factors in his own locally adapted material, a great deal of that valuable time might be saved. Moreover, the breeder could devote a larger share of his program to improving the yield, quality and other characteristics of his crop varieties.

The induced mutation method offers that possibility. Certainly the recent back-mutation work with *Neurospora* provides convincing evidence that "positive" as well as "negative" directional genetic changes are responsive to artificial mutagenic agents.

You may ask why the results from earlier plant mutation studies have not been as convincing. I think the answer is in the reason microbial genetics is as prominent a field as it is today. Large populations can be studied with relative ease. Too, most maize mutation work which involved large populations was done using mature pollen. Perhaps for the mutagen treatments studied, cells at another stage might have been differently mutable. Those facts are still to be learned.

In addition, *Neurospora* genetics work indicates that the mutation of a locus to a recessive condition can be induced far more frequently than the reverse mutation of that same locus. Furthermore, most mutagenic agents tested have the capacity to mutate a locus in either direction. Thus, to obtain the data necessary for an adequate study of the mutation process in higher plants, as being distinct from, though perhaps related to the chromosome breakage process, we must study large population of treated and untreated material. The search for disease resistance as a mutant character should be profitable because methods of screening material for resistance to the attacks of certain pathogens can be applied on a massive scale.

BASIS FOR DISEASE RESISTANCE MUTATION STUDIES

There are sound reasons why disease resistance should occur as the result of artificial mutations. Most important of these is that there is often a rather delicate balance between the biochemical process of the host and those of the pathogen causing the malady. The nature of host parasite interaction is not known for wheat rust, but two general approaches have been taken to explain resistant or susceptible reactions. Resistance might be pictured as an inharmonious host cell-parasite interaction, and susceptibility a harmonious host cell-parasite interaction. In one of the approaches to the problem it has been hypothesized that because the parasite or pathogen can live on and derive food only from specific hosts, said pathogen may have a special requirement for one or more substances the host produces, e.g., the host may supply an amino acid or other compound the pathogen cannot make. If the host fails to produce the substance, the pathogen starves to death, thus a manifestation of host resistance. Race specificity could be readily explained by requirements for different specific nutritive factors. Kietz *et al* in their studies with *Venturia*, the apple scab fungus, have demonstrated that such a mechanism actually is operative. In the other hypothesis it is suggested that a toxic substance produced by the host cell might kill the parasite. Or, an antimetabolite produced by the parasite might cause the death of host cells the parasite requires to maintain itself, with the same end result. See Table 1.

TABLE 1

OBLIGATE HOST-PARASITE INTERACTION

I n t e r a c t i o n			
tion hypothesis	Inharmonious (resistance)		Harmonious (susceptible)
	Parasite	Fungus requires substance	Fungus requires substance
	Host cell	substance not produced in sufficient quantity by host	enough of substance produced
hypothesis			
A.	Parasite	fungus poisoned	fungus may not be sensitive to toxin
			or
	Host cell	"toxin" originates in host cell before fungus attack	no toxin produced in host cell
B.	Parasite	fungus produces "antimetabolite" directly or as a result of inadequate food supply, fungus starves	no "antimetabolite" produced by fungus
	Host cell	host cell sensitive to fungus toxin, cell dies, fungus starves	host cell sensitive but no toxin produced by fungus
			or
			host cell not sensitive to fungus toxin

The known genetically-controlled biosynthesis of adenine in *Neurospora* for example, might be considered to demonstrate a process that might be simulated in a plant system. (See Fig. 1). Let's suppose that adenine or a substance formed in a similar way is required by the parasite. Blocking the synthesis of that substance through a mutation at any step prior to the last, blocks the food supply for the parasite. It is assumed, of course, that the substance required by the fungus is not essential to the host, though the question may instead be of the quantity of a substance available in a pool from which the fungus can feed. It is known that many plants accumulate chemical compounds.

Another possible mechanism is also indicated by this example. If the host is supplied with the end-product of the synthesis reactions by some other pathway, (for these *Neurospora* mutants, of course, it is supplied in the medium) the last chemical substance formed is accumulated. In *Neurospora*, a genetic block preventing the formation of by

poxanthine results in the production of a new substance - one that is not formed in the normal organism. In this case it is a purple pigment, but in case of the hypothesized plant system, either the new substance formed or the one accumulated might be antagonistic to a parasite.

Teas and Anderson have shown that a radiation-induced maize mutant accumulates anthranilic acid as well as two other substances that fluoresce under ultraviolet light but is otherwise undistinguishable from normal plants. It is significant also that the genetic change is either dominant or recessive, depending on the criteria selected for identification of genotypes. Seedling plants heterozygous for the mutation are not fluorescent, but another tissue of the same plants fluoresces in the same way as these from plants that are homozygous for the mutation. The analogous mutation occurs in *Neurospora*. This demonstrates that the accumulation of substances as the result of a mutation may cause no harm to a plant. The same sort of change, however, may upset the harmonious balance between the host and parasite and bring about the incompatible interaction otherwise known as resistance. Furthermore, Flor has shown that a gene-for-gene relationship is responsible for the host-parasite interaction for rust reaction in flax. He has observed the following genetic interactions:

Genetics of pathogen

Genetics of host cell	A	Av	av
		R ⁺	S
	a	S	S

1. Resistance and avirulence dominant

A	V	v
	S	R
a	S	S

2. Resistance and virulence dominant

+ Resistant or susceptible interaction.

In each case, the only interaction resulting in resistance is that where the avirulence factor in the pathogen meets the resistance factor of the host. This would seem to suggest that the resistance mechanism involves a toxic interaction of host and parasite, but an interpretation via a nutrition hypothesis is not ruled out.

THE INDUCED MUTATION METHOD

The method involves simply the exposure of seeds or other plant parts to a mutagenic agent. This may be X-rays, gamma rays, thermal or fast neutrons, radioisotopes, ultraviolet light, or any of a number of chemical agents. The mutagenic agent alters the genetic material (i.e. chromosomes or genes) such that mutant types segregate out in the following generation. Sectors may also occur in plants from treated seed clones or an effect of pollen treatment may be observed in the first generation. Mutants are isolated in the segregating generation, and propagated thereafter in the same manner as from the F₂ in an advanced backcross.

In its present stage of development, the induced mutation method appears to offer the following potential or actual advantages: (1) single characteristics of a variety may be readily improved; (2) the time required to make simple improvements may be less than by any other method; (3) improvements should seldom be accompanied by undesirable alterations of other characteristics, and even if this should occasionally happen, mutants are usually enough like their parent variety that a few backcrosses would restore the desired factors; (4) when the desired mutations can be induced, it should not be necessary to obtain them from unadapted sources; desired improvements in characters known to show quantitative inheritance may often be duplicated by simple inherited artificial mutations; for example, some erectoides mutants in barley shorten plant height and rachis internode length; (5) the possibility exists that the genetic nature of disease-resistant mutants induced in locally adapted varieties may differ sufficiently so that the "mass culture" as a basis for the spread of diseases like stem rust will be less important; (6) the method is not necessarily limited by the adaptation of parental material; (7) the method may be a means of obtaining variability in cases where natural sources are not known. Gregory in his research with peanuts has already shown this to be important, and (8) the method might conceivably provide better research tools such as "isogenic" lines useful for the identification of races or pathogens or in the study of the nature of disease resistance and in biochemical genetics studies.

The following disadvantages or difficulties are now evident: (1) practical use is limited to the improvement of small numbers of characteristics for which selection can be accomplished with efficient screening methods; (2) it is usually necessary to screen large populations requiring rather extensive field operations; (3) crop varieties vary in their mutability response; this indicates that the recovery of a particular mutation may sometimes depend upon the genetic constitution of the plant and the mutagenic agent employed; (4) chromosomal deficiencies or other aberrations may be induced and carried along with or linked to a desired mutation. Partial sterility may occur and cause the failure of reproduction of the mutation, or instability may result; (5) the presently applied mutagen treatments are not as efficient at producing useful mutations as might be desired.

A procedure we have developed in the course of our studies and in our work cooperative with Dr. Borlaug and Mr. Acosta of the Oficina de Estudios Especiales, S.A.G. in Mexico, is presented in Figure 2. The application of the mutation method is the same as previously outlined. However, the reasons for testing the R_2 or second generation have not been mentioned and are quite important. These are: (1) Changes induced in the cells of the seed are most often reproduced in only rather small sectors of the R_1 plant. (2) The R_2 is the segregating generation, and whole plants possessing a mutant character are easier to identify than the mutant sectors. Also some disease or cold-hardiness tests would eliminate the weakened R_1 plants, but would permit proper identification of individual R_2 plants. (3) A reshuffling of altered chromosome parts at meiosis may be responsible for the appearance of some mutant characters.

Another important part of the procedure is the use of plant progeny tests rather than tests of head progenies, because it considerably reduces the work involved. In using the procedure, however, careful handling, testing and isolation of parental and R_1 progenies is of critical importance. Radiation induces sterility and natural crosses might occur if the first generation is not isolated from other varieties of the same crop. Mechanical mixtures would likewise yield misinformation.

TABLE 2

PROBABLE MUTANTS RECOVERED IN R_2 FROM IRRADIATED LERMA

Number of Progenies in Treatments:

Plant Reaction Type	15,000r x-Rays	1.1×10^{13} Nth.	Control
O	3		
TR	3		
TMR	1		
TMS	1		
5MR	2		
5MS	2		
10MR	2		
10MS	5	1	
10S	1		
15MR	1		
20MR	3		
20MS	2		
Total	26	1	0
Total tested	615	51	75 (Bulked)
Percent mutants	4.3	2.0	0

An important factor favoring the success of our cooperative research has been the severe disease conditions that can be developed at the experimental stations in Central Mexico. In local areas susceptible wheat may be completely killed by rust by the time it heads out. Such conditions greatly simplify the selection for resistant plants.

SOME RESULTS OBTAINED

Some evidence of the potential value of the mutation method as an aid in plant breeding is indicated in experimental data already available from a number of different institutions. A portion of the encouraging positive results has been obtained with wheat in our tests and in the tests of Ausemus and Hsu at the University of Minnesota. Mac Key in Sweden also observed rust resistant mutants. The Minnesota work presented here by Dr. Ausemus shows the appearance of two types of resistance to stem rust race 15B in Lee spring wheat. R_2 lines of irradiated Lerma wheat from our cooperative tests were exposed to natural stem rust infection (mostly race 29) in Mexico during the summer of 1955 with the result that several de-

grees of mature plant resistance were detected. The frequency of the mutants is given in Table 2. The results are tentative since they have not been confirmed by greenhouse or field tests. The tests are in progress, however. The gradation in types of mature plant reaction observed is most impressive because it indicates that the same range of reaction types as occurs in nature can be produced with mutagenic agents, and that the selection for resistance to a natural rust population is possible. It appears that the dominant race is the one that makes the basic selection. It would probably not be advisable, however, to release a mixture of races in a test nursery. Other mutants of special significance have appeared in our tests. In Lerma there were short-strawed types with normal sized spikes. In Gabo, types 1, 2, and 3 of resistance to stripe rust, caused by Puccinia glumarum, were identified. The Gabo parent showed a type 4+ reaction on the scale of 0 to 5. Awned mutants also appeared in the Gabo Material. These mutants have agronomic value. Awned varieties are preferred by farmers in areas where combine pick-up harvesting is important because the more fluffy swaths of awned varieties dry better than those of awnless types. The recessive awned types appear to be obtainable readily from irradiated awnless varieties.

Mutation studies with other cereals have been at least as rewarding. The following is a list of a few useful mutants that have been obtained: Stem rust resistance in oats has been obtained by Konzak, Frey, and Myers and Koo. An oats mutant resistant to crown rust has been obtained by the Iowa workers (Frey, personal communication). Short-strawed mutants have been induced in barley by several investigators (including Gustafson in Sweden, Shebeski and Lawrence in Canada, Lambert in Minnesota, and apparently also by Suneson and Schaller in California, though the list is probably more extensive). A short-strawed mutant was obtained recently in Century Patna rice by H. M. Beachell, U. S. Department of Agriculture, Agricultural Research Service. (Personal communication). This mutant may be particularly important for the control of lodging in rice because the reduction of the plant height is brought about by a reduction in the elongation of only the lower internodes. The panicle and grain size is the same as in the parent variety. Resistance to Victoria blight in oats has been induced in our laboratory. The frequency at which this mutation occurs is given in Table 3. There are indications that the blight resistance may be induced without the loss of the associated crown rust resistance.

There is, therefore, some evidence that the induced mutation method can be useful to plant breeders. How might it fit in with other methods now utilized? If we consider the objective of plant breeding from a rather broad viewpoint, the method might be visualized as another supplement to the methods breeders now employ in their quest to direct the appearance, recombination and distribution of genetic variation in crop plants. One might say that the method can provide greater control over the appearance of the genetic variation the breeder is so dependant upon.

In this paper an effort has been made to present the idea of the

induced mutation method and to discuss ways in which it might prove of value to the plant breeder. The development of the method is still in its infancy and it is important to distinguish between what appears to be the potential of the method and what has already been accomplished. Our present application of the method is hardly at maximum efficiency. We are limited by the "hit or miss" approach that must be taken because we cannot yet direct the mutation process. However, there is hope that in the relatively near future it will be possible to recommend treatments that may increase the frequency of induced mutants or modify the specificity of mutant types recovered. Improvements in techniques for applying mutagens or for isolating mutations will also increase the value of the method for practical plant breeding.

Table 3.- Frequency of Victoria-blight resistance mutations induced in Tama oats by radiations.

Seed treatment	Number of Progenies	
	Tested	Showing Mutants
Thermal neutrons ($1.5 \times 10^{13} \text{N}_{\text{th}}/\text{cm}^2$)	279	6
Thermal neutrons ($7.6 \times 10^{12} \text{N}_{\text{th}}/\text{cm}^2$)	363	4
X rays (25,000 r)	122	3
Control (on irradiation)	140	0

Results of different methods of breeding in small grain improvement at Purdue University.

Fred L. Patterson, John F. Schafer, Ralph M. Caldwell
and Leroy E. Compton.

The most rapid progress in small grain breeding often can be made by combining breeding for disease resistance concurrently with breeding for improved agronomic characters. For the most part disease resistance is governed by genetic factors easily selected for either in the back-cross or the pedigree, mass-pedigree or similar systems of breeding. Agronomic characters are often quantitative in inheritance and the greatest progress may be gained from systems of breeding other than the backcross which allow selection of superior types resulting from transgressive segregation. The success of such a program depends upon the diversity of germ plasm available and the relative frequency of superior types.

Backcrossing is nevertheless, considered complementary to other systems of breeding. It has been effective in introducing simply inherited characters into superior wheat types. These have been excellent parents in other systems of breeding. It provides a rapid means of correcting deficiencies in otherwise superior varieties and assures small gains should other methods of breeding not provide suitable improvement.

Both systems of breeding for disease resistance and agronomic type have been conducted at Purdue University. Disease resistance has been obtained from diverse sources and combined with adapted types by pedigree, bulk-pedigree and complex cross systems and by backcrossing. In these programs with wheat the backcross system of breeding has not produced a variety in competition with systems of breeding utilizing diverse sources of germ plasm and selection of transgressive segregants for agronomic characters combined with the desired disease resistance.

Three distinct steps in yield improvement have been accomplished (tables 1 and 2). Beginning with Trumbull for comparison, increased yielding capacity was obtained with Vigo developed by pedigree crossing using rather restricted germ plasm (table 1). Similar advance was made by C. A. Lamb in Ohio in the breeding of Seneca and Butler. The second step was accomplished with complex crosses utilizing diverse germ plasm. Knox and Vermillion resulted from a combination of characters from 7 original parents in a series of 6 crosses. Dual combines characters from 8 parents. In a later cycle of crossing involving materials similar to Knox, Vermillion and Dual, a third step in yield improvement is indicated (table 2). Four selections from hybrids 4746, 3 from 4546, 3 from 4521 and one from 4548 were tested in field plots at three locations in Indiana in 1955. All eight selections exceeded

Dual, the highest yielding variety from step 2.

In addition to yield these types have been improved for standing ability, reduced height, and disease or insect resistance.

During this same period disease resistance has been transferred to the best available types by backcrossing. The following types were developed but not released since the type could not compete with the varieties developed in other systems of breeding.

	Crossing completed	Possible release date
Trumbull ³ x Hope-Hassar	1939	1945
Thorne ³ x (Trumbull x Hope-Hassar)	1941	1947
Vigo ⁵ x (Malakof, P44-3)	1947	1953
427* x Wis. 245 (Timopheevi resistance)	1954	1961

* Vigo derivative with stem rust resistance from Hope.

A portion of the current breeding program is devoted to backcrossing. It assures small gains and provides excellent parents for pedigree or more complex systems of breeding. At the present time Knox, Dual, and Vermillion are being improved for one or more of the following characters:

- Seedling resistance to powdery mildew from Suwon
- Seedling resistance to powdery mildew from Michigan Amber
- Seedling leaf rust resistance from Agropyron elongatum
- Seedling leaf rust resistance from 3369 and 3616 (3848)
- Stem rust resistance from Red Egyptian
- Stem rust resistance from Agropyron elongatum
- Hessian fly resistance from P.I. 94587
- Loose smut resistance from Kawvale or Hope-Hussar
- Test weight from 4126

Should the hybrids developed in step 3 prove suitable in quality and continue outstanding in performance the above backcross derivatives would be of little value as varieties.

A similar improvement in yield and straw has been accomplished recently also with diverse crosses in winter barley at Purdue University. Earlier, similar advance was obtained in spring oats in crosses involving the Bond or Victoria varieties.

The evidence is accumulating that the use of diverse germ plasm and a system of breeding which allows selection of transgressive segregants can produce varieties which exceed the performance of varieties long grown in an area and considered well adapted. This has been true

for all small grains grown in Indiana and may well be true for most areas. This is not surprising when we consider that of the infinite possible genotypes only a few hundred were introduced by early settlers in Indiana and only a few thousand have been tested in breeding programs.

Table 1.- Steps one and two in yield improvement of Soft Red Winter wheat. Yield data from Lafayette, Ind.

Variety	Yield bu/a 7 Yr.Av.	Year of release	Source
Trumbull*	39.8	1916	Selection from "native" Fultz type
Step one in yield improvement			
Vigo	42.6	1946	Pedigree cross with restricted germ plasm
Butler*	43.7	1947	Do.
Seneca*	41.6	1950	Do.
Step two in yield improvement			
Knox	46.5	1953	Complex cross with diverse germ plasm
Vermillion	44.3	1955	Do.
Dual	48.8	1955	Do.

* Developed at the Ohio Agricultural Experiment Station, Wooster, Ohio, U.S.A.

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Table 2.- Step three in yield improvement. Lines from three crosses compared to Dual, highest yielding variety in step two. Data from Lafayette, Indiana.

Variety or hybrid	1953	1954
	bu/a	bu/a
Dual	63.4	61.1
4746 Diverse cross		
highest selection	69.8	68.2
mean of 20 selections	67.0	54.8
lowest selection	63.1	38.1
4521 Diverse cross		
highest selection	68.3	69.4
mean of 7 selections	64.8	62.2
lowest selection	59.2	49.7
4548 Diverse cross		
highest selection	65.6	73.7
mean of selections	64.5	71.2
lowest selection	63.5	69.0

Incorporation of Resistance Factors and Their Distribution in the Cultivated Varietal Complex for the Purpose of Neutralizing the Variations Being Produced in the Population of the Rust Pathogens.

Jose Vallega⁽¹⁾

Instituto de Fitotecnica, Castelar, Argentina.

In Argentina wheat breeding has been done by both private and official breeders, each working independently and in competition with one another. These programs have continuously been providing better and better varieties for the farmer. The contributions of the private breeders and of the Tribunal de Fiscalización de Semillas has been especially effective in increasing production. The greatest progress has been in the fields of developing varieties which possess better quality characteristics and greater yielding capacity. Nevertheless the newer varieties generally have not possessed adequate resistance to the principal diseases. Recognizing these deficiency of disease resistance in the commercial varieties the Instituto de Fitotecnica has currently assumed the responsibility of providing the basic information, and materials, and technical assistance to all breeders in the Republic, which is essential to the development of disease resistant varieties.

The program of the Instituto de Fitotecnica consists of using the best varieties and outstanding lines of each of the private breeders and crossing each of them with introduced lines and varieties which have shown outstanding disease resistance. In this way an attempt is made to incorporate all of the known factors for disease resistance into the best commercial varieties and the most promising lines. By choosing the best varieties and lines which have been developed by each of the private breeders for inclusion in this crossing program a broad base of adaptability is assured. Special attention is given to using varieties which have shown "tolerance" to diseases, especially rusts, under field conditions, since these types of resistance, although usually difficult to evaluate, have been of importance in the past in protecting the Argentine wheat crop.

After the commercial varieties have been crossed to the disease resistant parents by technicians at the Instituto de Fitotecnica, and the progeny from such crosses have reached the segregating generations the material is returned to the private breeder. The private breeders will make all future selections in this material, and thereby develop improved disease resistance varieties adapted to the zone where he is working. Since the Instituto has assumed the responsibility of incorporating several kinds of resistance into a large number of commercial

1) Other scientists of the Instituto de Fitotecnica who are collaborators in this program are Juan L. Tessi, Horacio J. Frecha, Pedro Rodríguez A., and Enrique Antonelli.

varieties of different origins the improved varieties which will be developed by such a program will be very different. When a number of improved varieties are developed from such a program and they are grown in the same region they will provide a type of "elastic" resistance which should function to protect the commercial crop against epidemics of rusts. This method will not give the same degree of protection, if we consider individual fields, as would a composite variety (based on mixing of a number of similar lines which differ for disease resistance) but nevertheless it offers considerable protection to the country as a whole.

Since Argentina is an exporting country in which uniformity in wheat quality is of paramount importance, the use of composite varieties does not seem feasible and the aforementioned system seems more desirable.

In the current program the following commercial varieties have been used as a base: Klein Cometa, Klein Lucero, Benvenuto Inca, Sinvalocho M. A., Klein 157, Massaux No. 5, Buck Quequen and Klein 32. The varieties which have been used as sources of resistance are:

1.- Resistance to Puccinia graminis

D.I.V.

6730 Magnif MG
7644 Magnif Disro 1
5111 Rafaela L.24
7132 Kenya Governor, C.I. 12100
7134 Kenya 58, C.I. 12471
7141 Kenya Farmer, C.I. 12880
7158 Yaqui 53
7135 Kenya 117 A, C.I. 13139
7155 Toluca 53
7144 Kentana 51 A, C.I. 13150
7129 Red Egyptian, RL 2061, C.I. 12345
7139 Kenya 321 B.T.1.B.1.
7149 Mayo 54
7130 Ethiopia, C.I. 7905
7142 Kenya 350, A.D.9.C.2
7191 Africa 43
7169 Gabo (Aguilera-Kenya x Pilot-Marroqui)
7178 Yaqui 48 - Kenya 58 Newthatch 3434-2y-4m
7127 Frontana x R.L.2265 Redman², C.I. 12876
7147 Egypt NA 101 x Timstein 704-1y-5y-5c-2c-1c

7668 Rojal de Almería
7209 St. 464, C.I. 13160
7214 Camadi Abdu tipo 103, P.I. 192168
7207 Baladi 116, C.I. 7265-1
7211 Tremez Molle, C.I. 7067-1-1c

(1) D.I.V. = Division of Plant Investigation.

2.- Resistance to P. triticina:

D.I.V.

6730 Magnif. MG
7677 Barleta 10
7693 Klein Titán
239 12 H 3 Percival-38 M.A.
7141 Kenya Farmer
7676 Klein Lucero
4790 Sinvalocho

7207 Baladi 116
7211 Tremez Molle

3.- Resistance to P. glumarum:

D.I.V.

7690 Chino 166 x Lin Calel
6730 Magnif MG
239 12 H. 3 Percival 38 M.A.
5066 Magnif G.

4.- Resistance to Erysiphe graminis:

D.I.V.

86 Axminster
88 Normandie

5.- Resistance to Tilletia spp.

D.I.V.

342 Klein Piramide
8 Hussar
1007 Martin
3977 Oro

6.- Resistance to Septoria:

D.I.V.

1614 Currel
3324 Oakley
235 Lin Calel
181 Mediterranean-Hope-Kawvale Tenmarq

7.- Resistance to Ustilago tritici:

D.I.V.

4790 Sinvalocho

In carrying out this program the backcross method is employed as far as is feasible.

Sec.1- 7

Progress in Breeding for leaf and stem rust
resistance in wheats adapted to Texas conditions.^{1/}

by

I. M. Atkins, D. E. Weibel and M.C. Futrell.

Early work on breeding for rust resistance in wheat in Texas resulted in the development of Austin, Seabreeze, Supremo and Quanah varieties which utilized Hope wheat as a source of resistance. More recently the resistance of Fronteira has been utilized with the distribution of Frisco, a soft winter wheat. Foundation seed of Crockett, a new high test weight, early maturing hard red winter wheat from a complex cross (Sinvalocho Wichita x Hope-Cheyenne) x Wichita, will be released to growers in 1956. While these varieties are improvements over those previously available to farmers, the recent changes in prevalence of races of leaf and stem rust have reduced the effectiveness of their resistance.

Even before these new varieties became important commercially, it was realized that a higher type of resistance to both leaf and stem rust was essential for adequate protection of the crop, to prevent overwintering and to extend the usefulness of the crop into South Texas where it could be utilized for winter pasture. Accordingly a systematic program to broaden the base of resistance was inaugurated at both College Station and Denton. Several South American strains were used because of their resistance to leaf and stem rust. Several Kenya strains were used, some of which later proved susceptible to race 15B. Leaf rust resistance from Exchange, Rio Negro, Frontana, La Prevision 25 and from Marquillo-Oro strains was used extensively in crosses.

When race 15B of stem rust became prevalent in 1950 it first appeared that resistant varieties were in immediate prospect. Two strains

^{1/} Prepared for the International Rust Conference at Mexico City March 18-24, 1956. A report of cooperative research carried out by the Texas Agricultural Experiment Station and the Section of Field Crops, A.R.S., U. S. Department of Agriculture.

from the College breeding program were named Bowie and Travis and increased for release. However, another rapid change in prevalence of races occurred with the return to importance of the older races 11, 29, 38, 48 and others, as well as biotypes of these, so it became necessary to cancel plans for release of these new varieties.

The breeding program at present incorporates the best resistance from these earlier crosses plus additions of germ plasm from many sources to give a broader base of protection to both rusts. Parental material used since 1950 include Kenya Farmer, Egypt Na 95, Egypt Na 101, derivatives of Agropyron from several sources and from other wheat relatives developed by the late E. S. McFadden, a number of strains developed in the Mexican wheat breeding program and some of the best strains developed in the spring wheat breeding program. Some lines from these crosses are now in the sixth generation and are being used in backcross programs with good commercial varieties.

There is a small acreage of durum wheat grown in the Edwards Plateau area of Central Texas. Before the advent of race 15B this was of little importance in the overwintering and early build-up of stem rust. Recently it has assumed much greater importance. Several crosses have been made to develop resistant durums for this area, and the new varieties developed in North Dakota are being tested for adaptation.

Until very recently facilities and personnel have not been available for detailed studies with pure races of rust so work was of necessity confined to field observations of reaction to natural epidemics or those developed by artificial inoculation under field conditions. Studies are now in progress on the inheritance of resistance to 15B in the Kenya-derived Bowie, in certain crosses of commercial hard wheats with Kenya Farmer, in Khapli emmer crosses and in certain other species derivatives. A new greenhouse is now being built which will make possible additional studies under controlled conditions.

The untimely passing of our friend, E. S. McFadden, will result in the loss of his valued assistance and thinking in this program for the control of rust. An effort will be made to carry on his work and possibly to publish some of his incompleated writings. Derivatives of his (Triticum dicoccoides x Aegilop speltoides) x Austin² have been crossed with several commercial wheats and this appears promising as a source of rust resistance. His last hybrid material involved a sister of Bowie with a Minnesota selection of Newthatch x Frontana. This material appears promising and is being fully explored.

Sec. 1 - 8

The Rust Resistance Breeding Program in Nebraska

V. A. Johnson and J. W. Schmidt

Ninety-nine percent of Nebraska's 78 million-bushel annual wheat production is hard red winter wheat. Although serious losses from stem

rust have not occurred in Nebraska for several years, heavy buildups of the disease have taken place in the state which undoubtedly contributed to the severe epidemics of recent years in the spring wheat areas of the United States and Canada. This, together with the fact that stem rust poses an annual threat to Nebraska's crop, has been instrumental in the accelerated rust resistance program now underway. Progress to-date in this program is reported herein.

An effort has been made to maintain as broad a germ plasm base as possible. Spring wheats have been the major source of stem rust resistance in the program although some derived winter-type materials also have been used. The main sources of stem rust resistance in use at Nebraska were reported at the international Wheat Stem Rust Conference at Winnipeg, Canada, in 1953 and need not be listed here. The Kenya wheats, particularly lines of Kenya 58 and 117A in combination with Mida and Newthatch, originating in Minnesota, have received special emphasis, primarily because of superior agronomic characteristics and resistance to races other than 15B. McMurachy-Exchange x Redman, Timopheevi derivatives, and Webster have been the other principal sources of stem rust resistance. The winter varieties Pawnee, Nebred, Cheyenne, and several Cheyenne x Hope derivatives have been used principally in the original crosses.

The backcross system has been followed with the first and in some cases the second backcross having been made. In successive generations beginning with the F₂, plant selections were made with a portion of the seed returned to the field and the remainder used for winter greenhouse rust tests. This has allowed backcrosses in the field based on the greenhouse rust reaction of the lines during the preceding winter.

Eight physiologic races of stem rust have been used thus far in the Nebraska program. They are 11, 15B, 17, 29, 38, 48, 56, and 139. Testing with 56, 38, and 17 has been limited to the field, whereas the other five races have been employed singly in greenhouse tests. The testing sequence has been as follows :

<u>Generation</u>	<u>Greenhouse</u>	<u>Field</u>
F ₂	Seedling reaction to 15B Resistant segregates propagated	No rust. F ₂ plants individually harvested
F ₃	Seedling reaction to 15B	Adult reaction to 15B. Resistant plants harvested individually
F ₄	Seedling reaction to 11 and 139.	Adult reaction to 15B 56, 38, and 17 composite.
F ₅	Seedling reaction to 29 Seedling and adult reaction to 48A	No rust. F ₅ rows harvested on basis of accumulated rust record in the greenhouse and field.

Cheyenne winter wheat and several advanced Hope-Cheyenne derivatives have been found to be highly resistant to races 29, 48A, and 139. Reaction of F_4 and F_5 segregates of Cheyenne crossed with spring wheats susceptible to these races suggests that a single gene or closely linked genes control the reaction of Cheyenne to these races. Resistance to one race was associated with resistance to the other two. Testing with any one of the three would have adequately established the reaction to all three. Plans have been made to further check this relationship by monosomic analysis.

Some 300 F_5 selections were tested for adult plant reaction to race 48A in greenhouse tests in 1955. The results when correlated with seedling reaction of the same selections to race 48A demonstrated that the latter is a reliable indicator of adult plant reaction. Plants for the adult tests were not propagated in the greenhouse but were obtained from the field in mid-March. A sod plug cutter was used to obtain a core containing the seedling plant. The cores were transferred to 4" clay pots and given fertilizer and supplementary lighting in the greenhouse. This treatment brought the plants into head within one month from the time they were brought in from the field. Inoculations were made by the talc-dust method. The core technique was sufficiently satisfactory that further use of it is intended for future rust testing of adult winter wheat plants.

Sec. 1 - 9

Plant Breeding in the Rust Area of Canada

A. B. Campbell

Cereal Breeding Laboratory, Winnipeg, Man.

At Winnipeg we are breeding for an area in which both stem and leaf rust resistance are essential -- an area in which some 6 million acres of hard red spring wheat are grown each year. Along with the problem of getting resistance to both rusts we have an even more difficult problem of maintaining a high standard of quality. Marquis has been our minimum standard of quality for many years. Thatcher, which still occupies 53% of the wheat acreage in Western Canada, has even better quality than Marquis. Thatcher is also well adapted and high yielding over a large area and under varying climatic conditions. Our goal then, is a rust resistant variety with excellent quality which is widely adapted and high yielding, and which is suitable for the combine method of harvesting.

Time has been a particularly important factor in our production of new varieties. New rust races have been appearing with disturbing regularity. This means that new varieties with resistance to these new races must be produced quickly. Testing of the milling and baking quality of new varieties has been rigorous and lengthy. We have reached

the point where it takes at least as long to test a new variety as it does to produce it.

The backcross method of breeding appears to be the most efficient answer to all of these problems and an intensive program was begun in 1951. The first derivatives of this program are Lee⁶-Kenya Farmer and Thatcher⁶-Kenya Farmer. These varieties were widely tested in our Co-operative Tests in 1955 and appeared to be equal in all respects to their recurrent parents.

The following tables indicate the present status of our backcrossing program:

<u>Completed Backcrosses</u>		<u>Character Added</u>
Thatcher ⁷	x Kenya Farmer	stem rust resistance
Lee ⁷	x "	"
Redman ⁷	x "	"
Thatcher ⁷	x Frontana	leaf rust resistance
Lee ⁷	x "	"
Redman ⁷	x "	"
Lee ⁶	x Thatcher	loose smut resistance
<u>Combined Backcrosses</u>		
Thatcher ⁶ -Kenya Farmer	x Thatcher ⁶ -Frontana	
Thatcher ⁶ -	x Thatcher ⁷ -	"
Lee ⁶ -	x Lee ⁶ -	"
Lee ⁷ -	x Lee ⁷ -	"
Redman ⁷ -	x Redman ⁵ -	"
Redman ⁷ -	x Redman ⁶ -	"

These are still in early generations and will of course require purification for stem and leaf rust resistance.

Backcross Derivatives as Parents

Little has been said of using backcross derivatives as parents in crosses. Such crosses would appear to have great possibilities. We have the following hybrid material, at present in the F₃ generation:

Selkirk x (Thatcher⁶-Kenya Farmer)
 Selkirk x (Lee⁶-Kenya Farmer)
 (Thatcher⁶-Kenya Farmer) x (Lee⁶-Kenya Farmer)

Backcrossing in Progress

Additional backcrosses have been started as further material becomes available. Some of these will be dropped as they are proven unsuitable or infeasible, but at the present time we have the following:

<u>Material</u>	<u>Character being transferred</u>
Selkirk ⁵ x (Redman ⁴ -Kenya Farmer)	stem rust resistance
Selkirk ⁴ x (Redman ³ -Frontana)	leaf rust resistance
Selkirk ³ x Exchange	additional leaf rust resistance
Selkirk x Lee	awns
Selkirk x McMurachy	root rot resistance
Thatcher ⁵ x Lee	awns
Chinook ⁵ x Kenya Farmer	stem rust resistance
Chinook ² x Frontana	leaf rust resistance

(Note: Chinook is a variety resistant to the wheat stem sawfly).

The most recent additions to our program, which are being used with both Selkirk and Thatcher, are :

1954 International
Wheat Rust Nursery No.

Colotana 266/51	523	P.I. 214392
Mentana-Rhodesian C. 12273	93	Peru II.138.46, 43-52
Mida x McMurachy-Exchange	297	Minnesota II-47-26
Frontana x Kenya 58-Newthatch	293	Minnesota II-50-25
Kenya 360.H	78	
Mayo 54	176	Mexico 2156-6c-4y-1c

These varieties are being used for their stem rust resistance. 1088-Yaqui (Mexico 2373-14y-1c-3y-1c-1y-2m) is being used for its shattering resistance.

Sec. 1 - 10

Durum Wheat Breeding in Canada.
A. B. Masson.

The current problem caused by race 15B of stem rust has practically forced farmers in the durum area of Manitoba and Eastern Saskatchewan to give up production of this crop. Nevertheless, Canada harvested an estimated 17 1/2 million bushels of durum wheat in 1955. This supply

is adequate to meet the existing demand. The main production in 1955 came from western Saskatchewan and Alberta where stem rust is not a serious factor, and it is evident that much larger quantities can be grown in this area.

Since 1950 the chief objective of durum breeding programs has been to develop varieties with resistance to race 15B stem rust. Two new varieties showed considerable promise and were increased as rapidly as possible. A winter crop was grown in Arizona during the winter of 1954-1955 and in the fall of 1955 some 45,000 bushels were harvested in Canada. Unfortunately these two varieties R.L. 3206 and R.L. 3207, proved to be inferior to Mindum in macaroni quality and were therefore discarded. They derive their resistance from Golden Ball and Iumillo and have inherited kernel characteristics which make the grain samples indistinguishable from the poor quality variety Golden Ball. The visual inspection of the grain samples is an important factor in the Canadian grading system. In 1955 a biotype of race 11 attacked R.L.3206 rather severely and R.L. 3207 showed segregation to this biotype. The existing supply of seed will be sold as commercial grain and not used for seed.

The main sources of stem rust resistance used at Winnipeg are as follows:

R.L.1714,	Golden Ball x (Iumillo-Mindum)
P.I.94701,	from world collection
C.I.3255,	"
St. 464,	"
C.I.7809,	"
Ld. 368,	from North Dakota, R. Heerman
R.L.3206,	(Bald Medeah x Iumillo-Mindum) x Carleton ²) x R.L.1714
R.L.3207,	(Bald Medeah x Iumillo-Mindum) x Carleton ²) x R.L.1714

The general plan is to use these varieties as donors of rust resistance in a backcross program. The main varieties used as recurring parents are derivatives of Nugget wheat having good macaroni quality but better straw strength than Nugget.

Sec. 1 - 11

The Breeding of Durum (Candeal) Wheats In Chile.

Rene Cortazar.

It is pointed out that in recent years in Chile there has been a serious shortage of durum wheat for macaroni and spaghetti production. The cause of this shortage is twofold. Consumption of these products has tripled since 1938, and in recent years production has been very adversely affected by losses from stem rust.

When the stem rust races changed several years ago and led to serious losses in the durum crop more than 400 durum wheat varieties from different parts of the world were studied intensively in an attempt to find a suitable variety, to replace the variety Capelli which had become susceptible. Although a number of varieties were found which possessed the necessary resistance none of them were satisfactory from an agronomic viewpoint. Consequently a large scale breeding program was initiated to solve this problem.

During 1955 two thousand tons of seed of a new variety developed from this breeding program was made available to farmers. This new variety was developed through a backcross program. The parentage of the new variety is Capelli³ x Giza. This new variety combines the stem rust resistance of Giza with the adaptation and good agronomic characteristics of Capelli. It is believed that the release of this new variety will do much to increase durum wheat production.

Sec. 1 - 12

Composite Wheat Varieties in Colombia

John W. Gibler, Joseph Rupert, and Luis Pena A.

The problem of breeding for disease resistance in Colombia is complicated not only by races of stem rust but also the necessity for resistance to races of stripe rust (Puccinia glumarum). To meet the threat of the ever changing shift in races of both rusts, a breeding program using the composite method was initiated. The program is based on the method evolved by Dr. Borlaug and co-workers in Mexico. Briefly, the basis for the formation of a composite variety is as follows: First, one must have as a recurrent parent a variety of good agronomic type, high yield and susceptible to one or more races of the pathogen. In a series of from 3-4 backcrosses, many different sources of resistance are incorporated into distinct lines of the recurrent parent. After the first backcross, the progeny of the second, third and fourth backcrosses must be tested with a tester race to which the recurrent parent is susceptible in order to eliminate the susceptible segregates. The backcrosses are made on resistant plants most closely resembling the recurrent parent in order to return to the parental type as rapidly as possible with the fewest number of backcrosses. At approximately the end of the fourth backcross, selections are made within the segregating progeny selecting for the same maturity, height and agronomic type as the recurrent parent. The resulting phenotypically similar lines are tested for quality and against the current prevalent races of the pathogen. This testing is done in the greenhouse and in some cases the field. They are also planted in special observational disease nurseries throughout the area. On the basis of these tests, approximately 10 lines are multiplied up to about 1 ton each and the seed thoroughly mixed. The resulting composite is a phenotypically similar mixture containing about 10 dif-

ferent genotypes for resistance. It is highly improbable that a race of the pathogen with the capacity to attack all 10 types of resistance would become prevalent. When a new race or races becomes prevalent to which one or more of the genotypic lines are susceptible, they are eliminated and replaced by resistant genotypic lines and a new composite is made up for release. Even if a new composite were not made up if only 30 or 40 percent of the composite population were susceptible, it would still be difficult for an epidemic to start. This would be analogous in trying to start a prairie fire in green grass that had only 30-40 percent dry leaves.

The varieties being used as recurrent parents with their reaction to stem and stripe rust are given in Table 1.

Table 1.- Varieties Used as Recurrent Parents in the Composite Breeding Program in Colombia.

Name	Origin	Reaction to	
		Stem Rust	Stripe Rust
Frocor 316	Brazil ^{1/}	S	R-MR
Menkemen 626	Mexico ^{1/}	S	S
Bonza	Mexico ^{1/}	R	R-MR
Gabo	Australia	S	S

^{1/} Selection made in Colombia.

There are 126 Triticum vulgare Host and 30 Triticum durum Desf. varieties being used as non recurrent parents for stem and stripe rust. These sources of resistance are being discussed in another paper. At the present time the first backcrosses have been made and in a few cases the second.

Sec. 1 - 13

Studies that are being conducted in Mexico to obtain greater resistance to the different rust races that attack Triticum vulgare, by means of inter-specific crosses.

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The Institute of Agricultural Investigations of the Ministry of Agriculture and Animal Husbandry, in an all-out effort to develop new varieties of wheat that are resistant to rust, has worked for

many years with numerous crosses of *Triticum vulgare*, during which it has obtained genetical plant material that is resistant to a large number of physiological races. However, this material after a relatively short period becomes almost useless due to the appearance of new races of rust, thus stressing the need for constant work towards obtaining new resistant wheats since the existing wheat varieties that are planted on a commercial scale will sooner or later have to be abandoned due to their susceptibility to the new rust races.

The wheat-breeding work now in progress, has been oriented fundamentally towards finding resistance to the different races of *Puccinia graminis tritici*, that have caused severe losses in the important wheat growing countries.

The majority of the studies we have carried out, have been with crosses between wheats of the same specie that were notable in their resistance to certain races of stem and leaf rust, possessed high yields, and good milling quality. However, in spite of all efforts, it has not been possible up till the present to obtain a wheat variety that is practically immune to the aforementioned rusts.

Until the year of 1940 only field tests had been carried out with numerous wheat varieties, the results of which indicated that some of these possessed valuable agronomical characteristics, good grain quality and a certain degree of resistance to *Puccinia graminis*. These varieties were used in 1940 as progenitors in the initiation of the wheat-breeding program for the production of new varieties that would be even more rust-resistant.

In the initial stages of this program, the varieties Marquis, Reward and Marroqui 588 were extensively used as progenitors due to their good yields of high quality grain and medium rust-resistance and these were crossed with the Hope variety which was used as a source of greater rust-resistance.

In 1944 a change occurred in the rust races present in Mexico, and the Marquis variety lost its rust resistance in Central Mexico, with the result that the lines of the crosses in which it had been used could no longer be considered for commercial plantings.

However, these lines of wheat were not discarded but instead the most promising were used as progenitors for making new crosses with the Thatcher and Newthatch varieties, which were known to be source of additional resistance to the new rust races that had made their appearance. This was done because it is an established policy in the wheat breeding program of the Institute of Agricultural Investigations that no promising wheat variety that suddenly loses its rust-resistance due to the appearance of new rust races, is ever definitely discarded from the program, but instead when this occurs, the best available lines that possess good resistance to the rust races initially prevalent, are used as progenitors in crosses made with a line of wheat that is resistant to the new races. In this manner it is expected

that greater success will be achieved in the formation of genotypes characterized in possessing the greatest possible number of genes that furnish resistance to the different rust races.

Again during the year of 1948, new rust races appeared and on that occasion the Supremo 211 variety was used as a progenitor with resistance to the new races. Simultaneously, that year the Kenya 324 and Kentana varieties, and variety No. 718 (Frontaira x Kenya x Gular) were also used as resistant progenitors.

The choice of these three latter varieties was very fortunate indeed, since they also possessed resistance to rust race 15B, which appeared in Mexico during 1950.

During the last few years some lines of crosses between Egypt x Timstein and Hope x Timstein, have been utilized as sources of additional rust resistance.

It is important to point out that some of the lines derived from crosses made during the early stages of our program, have up till the present continued to be resistant to the different races of rust that have been present in our wheat growing areas (Valley of Mexico, El Bajío, States of Sonora, Coahuila and Tamaulipas), in spite of the fact that under such a wide range of conditions these varieties presumably have been exposed to attack of a large number of different rust races during a period of more than 10 years.

In this respect Cross No. 5 which was obtained by crossing the Marroqui 588 and Thatcher varieties deserves special mention, since in addition to having good rust resistance it produces flour of very high breadmaking quality. The wheat varieties Noroeste, Nayar, Cibola, Bacatete, Verano, Puebla, Culiacán and Sanalona, which are different lines derived from Cross No. 75, also have similar characteristics. Cross No. 75 was obtained by crossing the two following lines of wheat that possess moderate rust resistance:

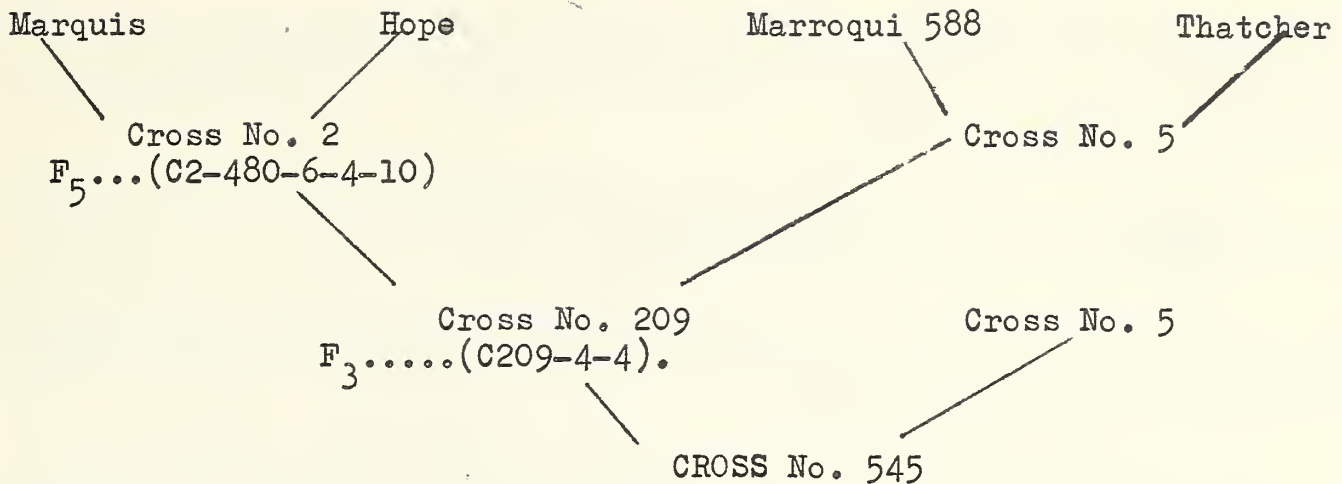
Cross 37-3 = (Newthatch x Selection 4 Aguilera)-3 and

Cross 4-2025-36 = (Mentana x Thatcher)-2025-36.

During the last three years Cross No. 75 has been tested in all of our wheat growing regions, from Chiapas to the Rio Grande (Bravo).

The progenitors of Cross No. 75 stress another of the criteria used in our wheat breeding program, which consists of that only individuals (or lines) that have shown a marked resistance in the segregating population of the F_2 or some more advanced generation, are used as progenitors for making new crosses, instead of using individuals of the F_1 population. This principle has been followed even in those cases in which it has been believed convenient to make backcrosses.

For example, the production of Cross No. 545 may be considered as a typical case, in which Cross No. 5 was used as the recurring progenitor in the back-cross in the following manner:



It is believed that this procedure is advisable, in spite of that it is much more time-consuming than uninterrupted backcrossing, due to the fact that it permits a selection to be made of the lines during various agricultural cycles on the basis of their rust-resistance and other agronomic characteristics.

At present work is being conducted with numerous planned crosses with the object of combining in one wheat variety, the genes of the outstanding progenitors that have been used in the past in our wheat breeding program.

The genetical material available for the obtention of a greater degree of rust-resistance has been derived generally from a relatively small number of wheat varieties, which in turn had their origin in crosses between Triticum vulgare and similar botanical species that characteristically possess an even greater degree of resistance to a larger number of physiological races of rust. When crosses are effected with related species and varieties of Triticum vulgare, the hybrids obtained generally are highly resistant to the races that are known at present in the wheat growing countries and in that manner a marked reduction is achieved in the sources of infection, without a decrease in the yields, the quality and the agronomical characteristics of the grain. For this reason it is of the utmost importance that greater efforts be made to derive from these closely related botanical species a larger number of genes of resistance that are capable of being incorporated into the wheat varieties that are adequate for bread-making, through use of the most promising lines of Triticum vulgare.

The Institute of Agricultural Investigations has carried out work with inter-specific crosses since the summer of 1949, using promising lines of Triticum vulgare which were very rust resistant with the object of exploring the possibility of crossing these varieties with Triticum dicoccum Khapli variety, which is highly resistant to a large number of the races and sub-races of rust that are known in our

country and abroad. After numerous attempts of hybridization in which great difficulties were systematically encountered, Cross No. 2 (C2-386-6-4-4-2) was finally crossed with Khapli, the resulting hybrid being called Cross No. 145.

During the present year this cross has been carried to the F₃ generation, with the designation C 145.

The characteristics of the plants pertaining to the selection 2-1 of Cross No. 145, which appears to offer the best agronomic possibilities, are the following :

Bearded spike, with white glabrous glumes and hard red grain. The heads are somewhat difficult to thresh due to a certain degree of fragility of the rachis and the great tenacity with which the glumes adhere to the grain. This hybrid is highly resistant to Puccinia graminis tritici.

The line C145-2-1 was in turn crossed, during the winter of 1954-55, with many lines of our best wheat varieties, and the combination of Cross No. 145 and Cross No. 5 has produced a new hybrid designated as Cross No. 708, the rust-resistance of which is now under intensive study.

The complete nomenclature of Cross No. 708 is the following:

C 708 = (C 145-2-1) x C5

Where: C 145-2-1 = ((Marquis x Hope)-386-6-4-4-2)x Khapli

C 5 = Marroqui 588 x Thatcher.

It is not known yet how much additional resistance can be expected from the use of line C145-2-1 as a progenitor, but the fact that it was possible to obtain this cross indicates that, with the necessary perseverance, it is feasible to derive from Khapli a larger number of genes than that now available for obtaining rust resistance to P. graminis, and a similar situation may be said to exist with regard to other species of graminacea that are botanically closely related to Triticum vulgare.

Sec. 1 - 14

Wheat Production and Wheat Breeding in Ecuador.

José R. Galárraga.

The wheat producing area of Ecuador can be divided into two zones on the basis of elevation, and the disease problems which are strictly correlated with elevation. These zones are: 1) the Andean

Zone and 2) the Intermediate Zone.

1.- ANDEAN ZONE.

The principal wheat producing area of the Republic is the Andean Zone which is located in the high valleys and on the slopes of the Central Andean Ranges. The majority of the area cultivated in this zone lies at an elevation of from 2800 to 3300 meters, and is characterized by a mean temperature of 10°C. There are approximately 50,000 hectares of wheat grown in this area, and the cultivated area can conceivably be increased by 25,000 hectares. Yields are generally low, averaging 540 kilos (12 quintales) per hectare. Low levels of soil fertility and losses from rusts, especially P. glumarum are primarily responsible for these low yields. Although stripe rust is the most important disease in this zone, stem rust has sometimes caused considerable damage up to levels of 3200 meters. Currently 150, Frontana and Bola are the principal commercial varieties.

2.- INTERMEDIATE ZONE.

This zone includes those areas which lie between 2,200 and 2,500 meters above sea level in valleys situated both east and west of the Central Andean Cordillera. This zone is characterized by having a mean temperature of 14°C. All three rusts stem, leaf and stripe are important problems in this zone. The varieties which are currently grown are Manitova ("Manitoba"), Africano and 150.

3.- LOWER ALTITUDINAL ZONE.

During recent years the Ministry of Agriculture has made successful experimental wheat plantings with stem rust resistant lines introduced from Mexico and Peru. Wheat has never been grown commercially in these areas and further testing is necessary to determine the feasibility of this undertaking.

Breeding and Testing Program

A large testing program of introduced material is being carried on at the Experimental Station for Cereals at Izobamba.

Experience has shown that many varieties which were introduced and cultivated commercially for their resistance to stem rust have soon lost their resistance. This may in part be associated with the development of new races through hybridization. Berberis grows in abundance throughout the Andean Zone.

A breeding program has been initiated recently in which the principal "criollo" (local) varieties are being crossed with the most promising introductions from Colombia, Peru, Argentina, Mexico and the United States. Special emphasis is given to crosses which include the

best Colombian varieties and lines as one of the parents. Moreover, many of the Colombian lines show promise for use as direct introductions.

Table No. 1 summarizes the best sources of stripe rust resistance for Ecuadorian conditions. The varieties listed in Table 2 are in preliminary increase and represent the most promising material derived directly from introductions which were made a number of years ago. The lines and varieties listed in Table 3 represent the most promising crosses and varieties of more recent introductions. Many of these lines have been reselected under Ecuadorian conditions.

Table No. 1.- Sources of Resistance To Puccinia
Glumarum.

Registration No.	Variety or Cross	Origin
7284	Magnif "G" Castelar 49-4131, Line G I-3-3-1	Argentina
9805	McMurachy	Canada
9806	Chinese x A. elong. PW 327	Canada
9809	Selkirk C.T. 186, RL 2769	Canada
9858	K. 122 D C.I. 13139	Kenya
9862	K. 318 C.I. 12881	Kenya
9842	K. 117 C.I. 123742	Kenya
9838	K. C.I. 117526	Kenya
9840	K. 130 C.I. 118901	Kenya
10076	2563 x Lee C.I. 13157	N. Dakota
9863	Rew-H44-Rhod. C.I. 205709	Peru
9832	Lageadinho C.I. 197660	Italia
9777	Otto Wulf C.I. 12578	Argentina
9807	Frontana x RL 2265-Redm. ² . R.L.2520	Canada
9799	Frontana x K 58 P.I. 206048	Brazil

Table No. 2.- Promising Introductions which are now in Preliminary Increase.

Registration No.	Variety or Cross	Origin
740-1	Frondosa x (K-Gular)	Mexico
1697-1	Dundee x RL 595 x Ford	Australia
3577-1	Aguilera x Kenya	Mexico
3926-1	Frondosa x (K-Gular 9906)	Mexico
4779-2	Frondosa x (K-Gular 4913)	Mexico
4780-1-1	Timstein x Newthatch	Mexico
3719-1	Mida x Marroqui 422	Mexico
Viracocha No. 1	(Peru x Supremo) Peru	Mexico
4135	Mentana x K 9906) Mentana	Mexico

Table No. 3.- Lines and Crosses which Have Shown Promise in Preliminary Testing.

Registration No.	Variety or Cross	Origin
3505	Newthatch X Marroqui 588	Mexico
4016	Kenya x Mentana ²	Mexico
6143	Marquillo-Waratak-F-EB	Australia
7813	Frontana x II-44-29	U.S.A.
4607-1-3-1	Kenya x Marroqui 426	Mexico
785-2-2	Mentana x Rocamex 211	Mexico
8565	Kentana 48 x Yaqui 48	Mexico
4583-1-8-2	Mentana x Kenya	Mexico
4590-6-1-1	Newthatch x Mentana	Mexico
6218-1-1-3	K. C. 10866 P.I. 118904	Kenya
6357-1-1	Lee Hyb C.I. 3844	U.S.A.
609-1-3-6-1	Frontana select.	Chile
3391-1-16-1	P x (T. ² supremo x 41-116)	Mexico
3405-4-1-1-4	Mentana ² x Kenya	Mexico
3872-1-1-2-3-1-1	Mentana x Kenya 9906	Mexico
4011-1-1-2	Kenya 9906 x Marroqui 426 ²	Mexico
4586-5-1-1-1	Renown x Marroqui 588	Mexico
4593-1-2-1-1-1	Mentana x Renown	Mexico
7470-2-1	Surpresa x K-Gular	U.S.A.
6785-7-4-2-3	Bage x Kenya	Colombia
8140-6	Frontana x II-44-22	U.S.A.
9774	Bonza	Colombia
11228	Frontana - S x KT-yaqui	Mexico
11236	K 350 AD x Frontana	Mexico
11417	(Newthatch x Marroqui)x(Kenya-Mentana)Frontana (Several)	Mexico
A80-1-1	Frontana x Kentana	Ecuador
A89-1-1	(Gal. x K804) x Chinese	Ecuador
A94-2-1	Kentana x Chinese	Ecuador
A94-3-1	Kentana x Chinese	Ecuador
A123-1-1	(Newthatch x Marroqui) x Chinese	Ecuador
A172-4-3	Seg 7 x Frond-K-Gular	Ecuador
A206-1-2	Frond-K-Gul x Frontana	Ecuador

Wheat Production Problems in Bolivia.

Maximo Cabrera I.

Bolivia annually produces about 20,000 metric tons of wheat on an area of approximately 30,000 hectares, resulting in an average yield of 660 kilos per hectare (10 bushels per acre). The current annual consumption of this grain is estimated to be 160,000 metric tons.

Production of this cereal is limited by losses from diseases, low levels of soil fertility, scarcity of precipitation, and untimely frosts. Of these factors which limit production, the losses from stripe and stem rust are the most important. Stripe rust (P. glumarum) is a serious problem wherever wheat is grown commercially, but becomes especially severe at elevations of 2800 meters and above. In recent years in two areas where wheat production was formerly important this crop has been replaced by barley because of the serious losses from stripe rust. Stem rust (P. graminis) sometimes causes serious losses in the lower elevational zones where wheat is grown commercially. Races 11, 14, 15, 15B, and 17 have been identified by Ing. Jose Vallega from material collected in Bolivia by Cornel, Frank and Cabrera.

The experimental work on wheat at the present time is largely confined to testing lines and varieties introduced from other countries. A number of lines which were introduced from Mexico, Peru and Colombia are especially promising.

The experimental testing work on wheat is largely concentrated at the Agricultural Experimental Station "La Tamborada" lying at an elevation of 2550 meters in the state of Cochabamba, and at the Experimental Station "Belen" which represents the Altiplano (High Plateau), located on the margin of Lake Titicaca. Conditions at "La Tamborada" are adequate for selecting for resistance to both stem and stripe rusts. The "Belen" station, which is characterized by extremely low mean temperatures and high humidity is ideal for determining stripe rust resistance. The growth cycle at this station for spring wheats is from 10 to 13 months and for winter wheats from 15 to 18 months.

Sec. 2 - 1

Genes and Sources of Resistance in Wheat to Rusts

H. C. Young, Jr., and A. M. Schlehuber

In the breeding program sources of leaf and stem rust resistance include Kenya Farmer C.I. 12880 crossed with Concho, Comanche,

and Triumph now in F_3 and Timstein-Henry C.I. 13026 crossed with Ponca in F_3 bulks. From materials in the 1953 International Spring Wheat Rust Nursery of the 10 common wheats listed with both leaf and stem rust resistance the following 5 spring wheat strains were obtained:

- 1.- Lee-Frontana, C.I. 13201
- 2.- Frontana x Kenya 58-Newthatch, C.I. 13154
- 3.- Frontana x Kenya 58-Newthatch, II-50-18
- 4.- Mida-McMurachy-Exchange, II-47-25
- 5.- Mida-McMurachy-Exchange, II-47-26

These strains have been crossed with the hard red winter wheat varieties; Comanche, Concho, Cimarron, Pawnee, Ponca, Triumph, Westar, Wichita and Kanking.

As sources of leaf rust resistance Triticum sp.-A. elongatum x Pawnee, C.I. 13020 and certain Triticum sp.-A. elongatum derivatives have been used. In the breeding program these have been crossed with Comanche, Concho, Pawnee, Ponca, Triumph, Westar and Mq.-Oro x Oro-Tenmarq C.I. 12406. Mature leaf rust immune types have been backcrossed with strong quality wheats such as Comanche, Ponca and C.I. 12406 in order to increase quality. Second and third backcrosses will be made in 1956.

Triticum sp.-A. elongatum x Pawnee C.I. 13020 is highly resistant in the seedling stage to 11 leaf rust races now used in rust studies in Oklahoma (races 5, 9, 15, 21, 32, 35, 58, 105, 105A, 105B and 126). In the field this strain is immune to leaf rust. For genetic studies it has been crossed with Ponca C.I. 12128; Comanche C.I. 11673; Concho C.I. 12517; Kenya Farmer C.I. 12880; and RL 2563 x Lee C.I. 13157. The F_1 , F_2 , and F_3 generations of these crosses have been or are being tested in the seedling stage to leaf rust race 105B and in the field to leaf rust in general. All of the F_1 plants from these crosses have been resistant or intermediate-resistant in the seedling stage and immune in the field. Segregation in the F_2 generation ranged from completely susceptible to highly resistant in the seedling stage, but did not fit any known genetic ratio. Approximately half of the population was resistant in some degree and the remainder were completely susceptible. In the field, all of the plants which had shown any degree of resistance in the greenhouse were immune. Those which were susceptible in the greenhouse were quite susceptible as mature plants in the field. At this time only a few F_3 lines have been processed. Aniversario C.I. 12578 is also resistant to all of the leaf rust races listed above. It has been crossed with Nabob C.I. 8869, Ponca C.I. 12128, Concho C.I. 12517 and Comanche C.I. 11673. F_1 and F_2 generations of these crosses tested in the seedling stage with leaf rust race 105B indicate a single factor control with susceptibility dominant. Aniversario also has been crossed with the spring wheats Kenya Farmer C. I. 12880 and Gabo x Peru- Supremo-Peru, P. I. 185905-1. Segregation indicated two factors controlling resistance to leaf rust race 105A with susceptibility dominant.

A selection of the cross Wabash x American Banner C.I. 12757

resistant to all the races listed except race 35 has been crossed with Kenya Farmer C.I. 12880. In this cross resistance to leaf rust race 105B was dominant and controlled by one factor.

None of these crosses have been tested for reaction to stem rust. Crosses to be made this year for leaf rust resistance include:

- 1.- Sears' Chinese Spring x Ae. umbellulata leaf rust resistant type with (a) Concho, (b) C.I. 12871, (c) Improved Blue Jacket-Comanche Sel. III-1, and (d) C.I. 13020-C.I. 12406) x Cimarron.
- 2.- C.I. 12804 (Med.-Hope-Pawnee x Oro-III.#1-Com.) with (a) Concho, (b) C.I. 12871, (c) C.I. 12702 and (d) (C.I. 13020 x C.I. 12406) x Cimarron.
- 3.- C.I. 12871 (Ey. Bkhl.-Tq. x Oro-Med.-Hope) with (a) C.I. 13020, (b) Concho, (c) Imp. Blue Jacket x Comanche III-1 and (d) (C.I. 13020 x C.I. 12406) x Cimarron.

Sec. 2- 2

Sources of Rust Resistance in Winter Wheats

E. G. Heyne and C. O. Johnston

The transfer of stem rust resistance to winter wheats in Kansas has been from spring wheat sources and no commercial varieties with good resistance have been released. The present sources of stem and leaf rust resistances being used are from recombination of factors from different sources, Triticum timopheevi derivatives and Agrotricums.

Several selections from each of three crosses, Frontana x Mediterranean - Hope Pawnee, Centenario x Mediterranean-Hope-Pawnee and Ponca x McMurachy-Redman³ have given lines superior in adult stem rust resistance to the parents. They were highly resistant in 1954 and 1955 when race 15B was the most prevalent race. They are also resistant to race 29. These selections are being crossed back to Kansas winter wheats as they lack winterhardiness. They are also resistant to a large collection of leaf rust races in the adult stage.

Shands 473 x Cheyenne, a timopheevi derivative, is also being used in the breeding program.

The Agrotricums, derivatives of crosses between Triticum sp. and Agropyron sp. have been studied in Kansas for 15 years. There are three types of material: 1) Wheat-like types with 42 chromosomes; 2) Wheat-like types with 42-44 chromosomes, and 3) intermediate types

with a higher chromosome number of approximately 56. The first type appears to be a case of one Agropyron chromosome substituted into the common wheat complex. An example is Wheat-Agropyron x Cheyenne. This has 21 pair of chromosomes but when crossed back to Cheyenne the pairing in the F_1 was 20_{II} plus two univalents. The material is now in the F_3 generation and it appears that this one Agropyron chromosome carries high resistance to many races of leaf rust, moderate resistance to a number of races of stem rust (17, 38, 56, 15B), and resistance to a number of races of bunt. The second group appears to have an addition of one or two chromosomes from the Agropyron parent to the regular common wheat complement. The third group has good resistance to both rusts but in crosses back to common wheat the recovered wheat-like types generally lack stem rust resistance. It is fairly easy to transfer the leaf rust resistance to wheat-like types but more difficult to transfer the stem rust resistance.

Sec. 2 - 3

Sources of Resistance to Puccinia graminis tritici and
P. rubigo-vera tritici Being Used in Argentina.

Ing. José Vallega and Hugo P. Cenóz

Over the past twenty years a large number of wheats from many different countries have been evaluated for rust resistance. These wheats have been tested both in the field, and also in the greenhouse where they have been tested against the races which have been collected in Argentina and neighboring countries. Many wheats have shown resistance to a number of races of rusts but those varieties listed in Table No. 1 and No. 2 have shown the broadest coverage and therefore are considered to be the best sources of resistance.

In the case of the varieties listed as being resistant to P. rubigo-vera, it should be pointed out that none of them are resistant to all of the races and biotypes of this pathogen which have been isolated in Argentina. The list includes those varieties with resistance to the biotypes of this organism which are now most prevalent.

Table No. 1.- Varieties with Resistance to P.
graminis tritici.

<u>D.I.V.*</u>	<u>Variety or Line</u>	<u>Pedigree</u>
7172	Kenya-Gabo	3261-3c-2c-1c-2c
7147	Egypt Na. 101-Timstein	704-1y-5y-5c-2c-1c
7178	Yaqui 48 x Kenya 58-Newthatch	3434-2y-4m
7155	Toluca 53	2254-8c-2y-2c-2y
7141	Kenya Farmer	P.I.187165-1c
7132	Kenya Governor	Egypt Na. 101, C.I.12100
7134	Kenya 58	C.I. 12471
7135	Kenya 117A	R.L.2767, C.I. 13139
7138	Kenya 291.J.1.I.1	P.I. 177172
7139	Kenya 321.B.T.1.B.1	P.I. 177179
7142	Kenya 350.AD.9.C.2	P.I. 177185
7201	Bowie	Texas 3708-22,C.I.13146
6730	Magnif MG	Castelar Magnif 27
7644	Magnif DISRO 1	
7127	Frontana x R.L. 2265-Redman 2	R.L. 2520, C.I. 12876
7146	Timstein-Kenya	702-3y-2y-1c-1y-1c
7169	Gabo (Aguilera-Kenya)(Pilot- Ma- rroqui)	2949-5c-1y--6c-3y-1m
7149	Mayo 54	2156-6c-4y-1c
7158	Yaqui 53	2257-15c-1c-5c-1c
7159	Yaqui 53A	2257-16c-1y-1c-2y-2c
7129	Red Egyptian	R.L. 2061, C.I. 12345
7130	Ethiopia	C.I. 7905, P.I. 60599
7144	Kentana 51	C.I. 13150
7153	Toluca 54	2254-1c-4y-3c-1y
7168	Cajeme 54	2730-1c-3y-3c
7214	Gamadi Abdu tipo 103	P.I. 192168 T. durum
7203	Arabian	P.I. 145720-1c T. durum
7209	St. 464	P.I. 191365,C.I.13160 T. durum

* Argentina Collection Number.

Table No. 2.- Varieties With Resistance To P. rubigo-vera

<u>D.I.V.</u>	<u>Variety or Line</u>	<u>Pedigree</u>	
468	Barleta 10		
396	Klein Titán		
4779	Klein Lucero		
4790	Sinvalocho M. A.		
403	La Previsión 25		
466	Barleta 25 c.		
474	7d I.F.L.E.		
3281	Klein 75		
225	Klein Progreso		
239	12-H3 x 38L.A.		
1132	Renacimiento		
7141	Kenya Farmer	P.I. 187165-1c	
7643	Africa No. 43		
7185	Kenya-Mentana x Frontana	P.225-1c-3y-2m-1y	
7201	Bowie	Texas 3708/22 C.I. 13146	
7192	P.I.170915-3c		
7123	Timstein	C.I. 12347	
7140	Kenya 338-AA-1.A.2	P.I. 177180	
7636	Selkirk	C.I. 13100	
7127	Frontana (R.L.2265-Redman ²)	C.I. 12876	
7146	Tismtein-Kenya	702-3y-2y-1c-ly--1c	
7175	(R.L.2265-Redman ³)Yaqui 50	3267-6y-9y-5m-ly	
7122	Gabo	C.I.12795	
7679	Lee		
7678	Exchange		
5630	Dickson's No. 444	P.I. 94588	T. durum
7639	Baladi 116	C.I. 7265-5	" "
7203	Arabian	P.I. 145720-1c	" "
7659	Tremez Molle	C.I. 7067-1	" "
7218	Ld. 308 x Nugget	Ld. 356, C.I. 13102	" "
7208	Gaza 277	C.I. 12616	" "
7656	Glutinoso	P.I. 174699	-
7672	Triticum Timopheevi	C.I. 11802	

Sec. 2 - 4

Sources of Resistance to Puccinia Graminis Tritici
 Erickss. & Henn. and Puccinia Glumarium (Schmidt)
 Erickss & Henn. which are being used in Colombia.

John W. Gibler, Juan Orjuela N. and Rafael París

The two principal diseases of wheat in Colombia are stripe and stem rust. Since wheat is grown commercially between an eleva-

tion of from 2000 to 3000 meters (6564 to 9846 feet) under moist conditions where there is considerable range in temperature it is absolutely necessary to obtain resistance to both of these diseases if the national production of this cereal is to be increased. Consequently the major emphasis in the breeding program has been to develop high yielding varieties with resistance to these two diseases. Conventional pedigree and backcross breeding methods have been used, and more recently an attempt is also being made to develop composite varieties.

The principal sources of resistance to these two rusts are shown in Table 1 and 2.

Table 1.- Sources of Resistance to Stripe Rust.

Name	Pedigree	Origin	Colombian Composite Variety No.
Bonza		Mexico	2
Chinese 166		China	3
Colotana	262/51	Brazil	5
Frontana	C.I.12470	Brazil	7
Frocor	F.R.316-6	Brazil	6
Frontana x Kenya 58-			
Newthatch	Various	Minnesota	8,9
Frontana x Yaqui	II-2629	Colombia	10
Frontana x Thatcher	II-1255	Colombia	12
Heines Kolben	-	Germany	13
Kentana-Frontana x Mayo 48	II-947	Colombia	16
Kenya 318 AJ.4.A.1	C.I.12881	Kenya	17
(Klein Cometa x Newthatch-Mentana) Menkemen	II-187-	Colombia	19
Lageadinho	P.I.197660	Italy	21
Lee	C.I.12488	Minnesota	22
Magnif G	P.I.197663	Argentina	27
Marroqui x Renown ²	CRI-281	Mexico	28
McMurachy	C.I.11876	Canada	29
McMurachy x Kentana-Yaqui	II-1571	Colombia	30
McMuracy x Mentana-Cinco	II-1572	Colombia	31
Mida x McMurachy-Exchange	II-47-26		
	C.I.13157	Minnesota	35
Río Negro	C.I.12469	Brazil	36
Selkirk CT.186	C.I.13100	Canada	40
South Africa #43	P.I.159106-1c	So. Africa	41
Timopheevi D 357 - 1	P.I.94761-1	Russia	43
150	P.I.190196	Ecuador	49
Triticum Persicum			
Fuliginosum	P.I.191395	Italy	1029
Africa x Mayo 48	3529-ly-4M	Mexico	50
Camadi Abdu Tipo 103	P.I.192168	Portugal	1001
C.I. 7513		Egypt	1002
C.I. 7800		Ethiopia	1003
C.I. 7805		"	1004

Table No. 1 (continued)

Name	Pedigree	Origin	Colombian Composite Variety No.
C.I. 7845		Ethiopia	1005
C.I. 7864		"	1006
C.I. 7995		"	1007
C.I. 8133		"	1008
C.I. 8154		"	1009
C.I.-8164-		"	1010
P.I. 193890		"	1011
P.I. 194043		"	1012
ST464	P.I.131365	"	1013
Tremez Rijo	C.I.7066-1-1c	"	1014
North Dakota 1	C.I.13157	N. Dakota	93
Reward H-44-24 x Egypt 101	P.I.205725	Peru	95
Thatcher x Mentana	II-1296	Colombia	103
Timstein x Kenya 2324	775-1c-3R 1BKR	Mexico	106
Transvaal Africa	P.I.170918	Africa	109

Table 2.- Sources of Resistance to Stem Rust.

Name	Pedigree	Origin	Colombian Composite Variety No.
Cadet	C.I.12053	N. Dakota	52
Chapingo 53		Mexico	53
Egypt 95	P.I.153780	Egypt	54
Egypt 101	C.I. 12100	Egypt	55
Egypt 101 x Timstein	704-1y-5y- 5c-2c-1c	Mexico	56
Frontana x Kenya 58-Newthatch	Various	Minnesota	--
Gabo	C.I.12795	Australia	59
Gabo 54		Mexico	60
Giza 139	P.I.210970	Egypt	61
Kentana 51A	C.I.13150	Mexico	62
Kenya 58-Newthatch x Frontana	II-1569	Colombia	63
Kenya 58 x Newthatch	II-44-29	Minnesota	65
Kenya 117 A	Canadian Sel.	Kenya	66
Kenya 321 BT I.B.1	P.I. 177179	"	70
Kenya 338 AA.1A2	P.I. 177180	"	71
Kenya Farmer	P.I. 187165-1c	"	74
Mariache 50	P.I.205738	Peru	76
María Escobar x A.V. 18			
1.1.1.1.1.	P.I. 205735	"	77
María Escobar x H44-Mar.	P.I. 205730	"	78

Table No. 2 (continued)

Name	Pedigree	Origin	Colombian Composite Variety No.
María Escobar x McMurachy	P.I.205723	Peru	80
Maribal 50	P.I.205736	"	82
Mayo 48		Mexico	84
Mayo 54		"	85
Menkemen 626		"	86
Mentana x Rhodesian	P.I. 205716	Peru	87
Mida x Kenya 117A	II-44-22	Minnesota	88
Newthatch	C.I.12318	Minnesota	91
Supremo 211-Kenya 324 x Yaqui	3533-3y-3M-2y	Mexico	100
Thatcher	C.I.10003	Minnesota	102
Timstein x Kenya 324	702-3y-2y-1c- 1y-1c-	Mexico	105
Toluca 53		Mexico	107
Wisconsin 245	C.I.12633	Wisconsin	112
Yaqui-(María Escobar ² -Supremo 211) x Timstein-Kenya 324)		Mexico	114
Yaqui 50		"	115
Yaqui 53		"	116
Yaqui 50 x Klein Cometa	II-664	Colombia	119
Yaqui x Kenya 58-Newthatch	3434-2y-4M	Mexico	121
466-4-MMM	P.I.159098	So. Africa	123
Klein 33		Argentina	125
C.I. 8155		Ethiopia	1017
Khapli	C.I.4013	India	1019
LD 364	C.I.13245	N. Dakota	1020
LD 368	C.I.13164	" "	1021
LD 370	C.I.13247	" "	1022
Tremez Mille	C.I.7067-1-1c	Portugal	1028

Although we have not conducted detailed greenhouse studies with the stripe rust organism, there is clearcut evidence from the field that indicates that there are at least two, and perhaps more, physiologic races. When Menkemen was released in 1953 it was resisted in all of the principal wheat growing regions to stripe rust. At the present time it is susceptible.

The stem rust races which have been identified from Colombia, by Dr. E. C. Stakman and co-workers of the U.S.D.A., include the following: 10, 15B, 38, 48, 78 and 151.

Wheat Crosses Which Are Showing Promise in Colombia

Mario Zapata B., Luis Alberto García and Reinaldo Reyes N.

There are three important wheat producing zones in the Andes region of Colombia, namely, the Provinces of Cundinamarca, Boyocá and Nariño. These zones lie at an elevation of 2600 meters (8533 feet) and have a mean temperature of from 13 to 15°C. The principal factors which limit wheat production in these areas are the rusts. Although all three rusts are present in the regions, stripe and stem are the most destructive, with leaf rust of only minor importance. The climatic and soil conditions of the three zones are sufficiently similar so that varieties adapted in one area are usually equally well adapted in another, except for the differences which exist from one area to another with respect to the intensity of Puccinia glumarum and P. graminis tritici. The adaptation of wheats in Colombia is influenced principally by the elevation and the precipitation.

Since 1950 two varieties, namely, Menkemen and Bonza have been distributed commercially. These two varieties yield from 30 to 40 percent more grain than the Criollo varieties Bola Picota and Ciento Cincuenta (150) which they have largely replaced. Moreover, the two new varieties mature from 30 to 40 days earlier than the criollos they are replacing.

Within the past two years a number of lines from a considerable number of crosses have shown outstanding promise. Some of these combine high yield, good resistance to stripe and stem rusts, desirable agronomic characteristics and good milling and baking quality. The most promising of these lines are currently being evaluated in yield tests at twenty different localities in the wheat producing areas of the Republic, and several of the best will be selected for multiplication.

The crosses which are currently showing outstanding promise are indicated in Table No. 1.

Table 1.- The Stripe and Stem Rust Reaction, and Quality Characteristics of the Most Promising Colombian Crosses.

Name of Cross or Variety	Cross Number	Reaction to:		Milling & Baking Quality
		<u>Puccinia glumarum</u>	<u>Puccinia graminis tr.</u>	
150 (Regional check)		R	MS	Good
Bola Picota (Regional check)		S	MS	Poor
Mentana 48 (Check)		MS	S	Poor
Frocor (check)		R-MR	S	Fair
Menkemen (check)		S	S	Fair
Bonza (check)		R-MR	R	Good
Kentana-Frontana x Mayo 48	II-947	R	R	Good
Mentana Resistente x Centela				
-Frontana	II-1523	R	R	Good
Gálgalos-Kenya x Newthatch	II-1560	R	R	Good
Salles-McMurachy x Mayo 48	II-1610	R	R	Fair
Lerma x Selkirk sib	II-1893	R	R	Good
Frocor x Kentana	II-2463	R	R	Good
Riccio x Yaqui-Kentana	II-2648	R	R	Good
Frocor x Yaqui-Kentana	II-2809	R	R	Good
Frontana-General Urquiza				
x Lerma	II-2821	R	R	Good
Supremo-Mentana x Marroqui-				
x Renown ²	II-4270	R	R	Good
Frocor x (McMurachy x Kentana) Yaqui 50	II-4777	R	MR	-
Klein Cometa x Mayo 54	II-4867	R	R	-
Kenya 350AD x Frocor	II-5084	R	R	-
Frocor x Kenya 350AD-Gabo	II-5140	R	R	-
Kentana x Thatcher-Mentana	II-5165	R	R	Poor
Kenya 58-Newthatch x Frocor	II-5169	R	R	-
Frontana-Yaqui x Mayo 48	II-5368	R-MS	R	-
Mayo 54 x Frocor	II-5816	R	R	-
Mayo 54 x Yaqui-Kentana	II-6105	R	R	-
(Frontana-General Urquiza				
x Mayo 54)x II-951	II-6206	R	R	-
Fortunato-#43 x Frontana-				
Thatcher	II-6239	R	R-MS	-
Klein Cometa (Newthatch-Mentana)				
Menkemen x Mayo 54	II-6424	R	R	-

(2) II-951 = (Kenya-Mentana)(Mentana-Supremo) x (Cinco-Newthatch).

Other sources of resistance being used in the breeding program at Minnesota.

E. R. Ausemus, D. W. Sunderman, K. J. Hsu

Many sources of resistance to stem rust, particularly to race 15B have been used in the breeding program. Much of the most resistant material is derived from Kenya 58 and 117A. More recently, Kenya Farmer, Selkirk, Khapstein and T. orientale x Agropyron have been used. New sources produced by hybridization of certain wheats such as Frontana x Thatcher, Frontana x K58-Newthatch, and Frontana x Kenya 117A-Mida have provided selections with very good resistance to both leaf and stem rust. The Kenya Farmer derivatives have not been satisfactory for quality and this has been true in general with the Kenya derivatives. The quality of some of the most resistant material is unsatisfactory but is used in conventional and backcrossing programs.

In winter wheat, leaf rust resistance is being obtained from Blackhawk, Klein Titan, two of the selections N.S. Nos. II-50-17 and II-50-18 and from certain crosses made by the Wisconsin Agricultural Experiment Station. Kenya 58 and Kenya 117A and their spring wheat derivatives were used for stem rust resistance particularly to race 15B. T. orientale x Agropyron which is highly resistant to both rusts in the field is being used as the non-recurring parent in a backcrossing program with winter wheat.

Many crosses and backcrosses are being made and studied for stem and leaf rust resistance where above mentioned resistant stocks are used as one of the parents. Some of the most promising material in the 1955 Rust Nursery was from a cross of (Frontana x Thatcher³) x (Kenya 58-Newthatch II-44-29 x Thatcher²). A number of these selections which were resistant to race 15B of stem rust in the seedling stage and resistant to both rusts in the field are being increased at Brawley, California this winter.

In crosses of T orientale x Agropyron with some winter and spring wheats, all were found to produce dwarfs or highly sterile F₁ plants, except with Selkirk. A backcross program is being used with Selkirk.

Another very interesting approach is the use of irradiation with both winter and spring wheats.

The Development of Stem and Leaf Rust Resistant Soft White Spring Wheats.

John Unrau

Pedigree and single and double backcross progeny involving Kenya AC₂E₃ as the source of resistance and the variety Lemhi have

been developed. In addition, some lines have been developed from outcrosses to a wheat x agropyron derivative. On a total of over 200 lines the stem rust reaction to race 15B₃ in the seedling stage was studied in 1955 and also to field reaction at Brooks, Alberta, Edmonton and Winnipeg in the summer of 1955. These same lines were grown at four locations in the irrigated area of southern Alberta. Agronomic data were obtained and studies have been conducted on various quantity characteristics of these lines. Data from these various studies are presented in summary form.

Sec. 2 - 8

Source of Resistance to Puccinnia graminis tritici
Which Have Been Used or Are Now Being Used in The
Mexican Breeding Program.

Aristeo Acosta, Ricardo Rodríguez and Manuel García

A large number of parents have been or are being used as sources of resistance to stem rust. These parents have been selected largely on the basis of their reactions in the International Wheat Rust Nurseries, as well as on the basis of genetic and greenhouse rust tests which have been conducted in many different countries. (Table No. 1).

Table 1.- Sources of Resistance to Puccinia graminis tritici Being Used in Mexico.

Variety or Line	P.I., C.I. or Pedigree	Country of Origin
<u>A. Bread Wheats</u>		
Egypt NA 101	C.I. 12100	Kenya
" NA 95	P.I. 153780	"
Kenya Farmer	C.I. 12880	"
Kenya 117A	C.I. 13140	"
Kenya 360 H	P.I. 177187	"
Kenya BTIBI	P.I. 177179	"
Kenya C 9906	C.I. 12882	"
Kentana 48		Mexico
Kentana 54		"
Mayo 54		"
Sinaloa		"
Yaqui 50		"

Table 1.- (Continued)

Variety or Line	P.I., C.I. or Pedigree	Country of Origin
Yaqui 53		Mexico
Yaqui 53A		"
Yaqui 54		"
Supremo 211	C.I. 12531	"
Egypt 101-Timstein	704-1y-5y-5c-2c-1c	"
Lerma Rojo		"
Selection 5		"
Yaktana (P14)		"
Thatcher	C.I. 10003	Minnesota
Newthatch	C.I. 12318	"
Lee	C.I. 12488	"
Willet		"
Timstein-Henry	II-44-65	"
Timstein-Kenya 58	II-30-1c	"
Kenya 58 x (Mida-Newthatch)	II-45-45	"
Lee-Frontana	II-47-10	"
(Mida-Newthatch) Kenya 117A	II-45-24	"
Frontana/Kenya58-Newthatch)	II-50-18	"
Mida-McMurachy-Exchange	II-47-26	"
Kenya 58-Newthatch	II-45-25	"
Lee-Mida Sib	646.8.18.4	N. Dakota
Mida	C.I. 12008	"
Frontana	C.I. 12470	Brazil
Rio Negro		"
Mentafen		Chile
Selkirk	C.I. 12894	Canada
RL 2520		"
Lee ⁶ -Kenya Farmer	C.I.231	"
María Escobar ² -McMurachy	6-42-1-R-1	Peru
María Escobar x(H-44 Marquis)	59-44	"
Mentana x Rhodesian	138-46-43	"
South Africa 466-4MMM	P.I. 159098	South Africa
No. 43	P.I. 159106	" "
Yaqui 48 x (Kenya 58-Newthatch)	3434-2y-4M	Mexico
(Mida x María Escobar) x (Egypt 101-Timstein)	2190-5c-2T-5H	"
Gabo	C.I. 12795	Australia
Kapstein		"
Kenya-Gular	C 5963	"
Magnif MG		Argentina
Cientocincuenta (150)		"

Table 1.- (Continued)

Variety or Line	P.I., C.I. or Pedigree	Country of Origin
<u>B. DURUMS:</u>		
St 464	P.I. 191365	Ethiopia
Unnamed Durum	C.I. 7790	"
" "	C.I. 7805	"
" "	C.I. 7809	"
Tremez Molle	P.I. 56258	Portugal
Tremez Rijo	P.I. 56257	"

Sec. 2 - 8A

Sources of Stem Rust Resistance Being Employed In
The Wheat Breeding Program at Rio Grande Do Sul, Brazil.

Mario Bastos Lagos

Stem rust is the limiting factor in wheat production in southern Brazil. The state government of Rio Grande do Sul in 1950 began a breeding program to develop high yielding stem rust resistant varieties. The principal varieties which are being used as rust resistant parents are introductions from the United States, Mexico, Peru, Kenya and Australia. (Table 1). The commercial varieties which are being improved in this crossing program are:

- 1) Early Maturing Varieties - Frontana, Colotana 59/51 and Trapeano.
- 2) Semi Early Maturing Variety - Bagé
- 3) Late Maturing Varieties - Colonias, Colotana 474/51 and Colotana 824/51

Table 1.- Wheat Varieties Which Are Resistant To Stem Rust.

A Group Resistant to Races 11, 15B and 17.

1. Bowie
2. Frontana (Kenya 58-Newthatch) II-50-17

Table 1. (Continued)

-
3. Gabo 54
 4. Kenya Farmer
 5. Kenya Governor
 6. Kenya 58
 7. Kenya 117A
 8. Kenya 321.BT.1.B1 .
 9. Kenya 338.AA.1.A.2
 10. Kentana 48
 11. Lee-Frontana II 47-10
 12. Maria Escobar x AV.18.1.1.1.1.
 13. Mayo 54
 14. Yaktana (P14) Various lines derived from cross of
((Newthatch-Marroqui)x(Kenya-Mentana))Frontana
 15. Rhodesian
 16. Supremo 51
 17. Yaqui 53

B Varieties Resistant to Races 11 and 17

1. Gabo
 2. Timstein
-

Sec. 2 - 8B

Differences in Infectibility among Spring
Wheat Varieties.

E. B. Hayden

All commercial hard red spring wheats were attacked by stem rust in 1950 when race 15B Puccinia graminis var. tritici first became prevalent and destructive in the United States. Certain wheats, including the bread wheats Lee and Rushmore, and the new durum variety Sentry, produced relatively high yields despite appearing as heavily rusted at maturity as the lower yielding Mida, Rival, Stewart, and Carleton. These rust-susceptible, but high yielding wheats have been termed tolerant to stem rust.

The progressive development of stem rust was critically observed throughout the past two growing seasons on both tolerant and non-tolerant varieties. Differences among varieties in prevalence and severity of stem rust were apparent early in the season when primary lesions developed, but often were obscured as stem rust became epidemic. The higher yields of certain rust-susceptible wheats

could generally be correlated with smaller numbers of primary lesions and later or less severe development of stem rust on particular plant parts.

Two-square foot areas of 11 spring wheats were artificially inoculated with 2.25 and 57.45 million urediospores of race 15B in 1955. Inoculum was subjected to unfavorable conditions for 4 days after inoculation before infection occurred. The number of primary lesions which developed per culm on individual varieties agreed well with the relative severity of stem rust attack on the same varieties exposed to inoculum of race 15B present in nature. Fewer lesions developed on tolerant varieties such as Lee (4.3 lesions) and Rushmore (7.3 lesions) than on the non-tolerant varieties Mida (10.0 lesions) and Marquis (23.5 lesions) when exposed to 57.45 million urediospores. Results were similar with both concentrations of inoculum.

Differences in infectibility among certain rust-susceptible spring wheats appears to be a factor contributing to the ability of these wheats to tolerate severe attacks of race 15B and produce relatively high yields. The usefulness of this phenomenon depends on the number of physiologic races against which it is effective; its mode of inheritance; and the development of techniques suitable for determining the presence of this characteristic in breeding lines.

Sec. 2 -8C

Field Resistance and Tolerance of Certain Varieties to Stem Rust and the Difficulties of Adequately Evaluating this very Useful Type of Resistance.

Norman E. Borlaug, José Rodríguez and Fernando Curiel.

Two Mexican varieties namely Kentana 54 and the "Criollo" ("native") variety Barrigón Yaqui exhibit very unusual field responses to stem rust.

Kentana 54, which was derived from a cross of Kentana 48 x Rfo Negro is susceptible in the greenhouse in the seedling stage to races 29, 48, 49 and 139. When adult plants are inoculated in the greenhouse they also exhibit moderate to complete susceptibility to these same races. Nevertheless when this variety has been grown commercially at high elevations under low temperature conditions in areas where these races are prevalent it has never suffered appreciable reduction in yield or in grain test weight despite the fact that it often exhibits from 60 to 80% infection of a moderately susceptible reaction. When this variety is grown adjacent to fields of Kentana 48 or other varieties that are highly susceptible to this group of races, it rusts more heavily than when it is isolated by some distance from large amounts of inoculum. When grown under isolated conditions where

the effect of inblown inoculum is reduced to a minimum, the rate of buildup of the epidemic seems to be delayed. Normally we think of this type of resistance as one which would be entirely unsatisfactory at higher temperatures. Nevertheless in the recent rust nursery report from the tests conducted in the Virgin Islands and Porto Rico by Theis and Rodenheiser, this variety remained virtually free from rust in nurseries where these same races were present and where rust infection was severe on adjacent rows of susceptible varieties.

Barrigón Yaqui is a "Criollo" ("native") variety of unknown origin belonging to the species T. turgidum. This variety was formerly grown very extensively in Sonora because of its resistance to stem rust. It is susceptible in the seedling stage under greenhouse conditions to all of the common Mexican stem rust races. Greenhouse inoculation tests with adult plants have shown that it is moderately resistant to all races except 15B, to which it is moderately susceptible. Nevertheless, under Sonora field conditions this variety has never rusted with race 15B even though fields have been located adjacent to heavily infected fields of Gabo or Yaqui. Nevertheless, when Barrigón Yaqui is grown at Chapingo or Mexe during the summer, under conditions of lower temperature and higher humidity, it is not unusual for it to develop from 20 to 40 percent of rust infection of the moderately susceptible type. The rate of lignification of the culms of this variety appear to progress much more rapidly under the high temperature conditions on the Coast of Sonora than it does under the low temperatures of Chapingo or Mexe. This difference in rate of lignification appears to be correlated with the difference in rust reaction under the two conditions.

The different reactions of these two varieties illustrates clearly the difficulty of obtaining a true evaluation of the merits of certain types of adult plant field resistance.

Sec. 2 - 9

WHEAT CYTOGENETICS RESEARCH AT THE UNIVERSITY OF MINNESOTA*

L. A. Snyder and C. R. Burnham, assisted by
L.L. Inman, C.P. Pi, and E. L. Turcotte

Major research emphasis at present is being placed on the development of chromosome substitution lines, and studies on the inheritance of available qualitative characters, mostly resistance to various stem and leaf rust races.

The donor varieties on which primary emphasis is being placed in the chromosome substitution program are Marquis, Mida, and Kenya

* Investigations supported in part by a grant from the Rockefeller Foundation.

Farmer (K338), the chromosomes of each of which are being substituted individually into a uniform background provided by the variety Chinese Spring. These donor varieties were selected on the basis of adaptation to Minnesota conditions and to provide a certain amount of phylogenetic and genetic diversity, the latter with particular regard to rust reaction. Chinese Spring was selected as the common recipient variety, or common background into which the individual chromosomes of the donor varieties are introduced, on the basis of generally poor adaptation to Minnesota conditions, the availability of required monosomic and monoisosomic or monotelosomic stocks, and the susceptibility of the variety to a large number of rust races.

Transfers of the individual chromosomes of the donor varieties into Chinese Spring are being effected by F_1 crosses to the proper Chinese Spring monosomic, monoisosomic, or monotelosomic, followed by 6 backcrosses to the appropriate Chinese Spring monoisosomic or monotelosomic. Various workers have been concerned about the difficulties involved in a phenomenon referred to as "monosomic drift" or "univalent shift", which relates to the fact that in a progeny of a given monosomic plant there may occur occasional plants which are disomic for the chromosome involved in the original monosomic parent but are monosomic for a different chromosome. The results from the commonly observed tendency of monosomic plants, either in monosomic stocks or in inter-varietal crosses, to have a somewhat higher frequency of desynapsed bivalents than do normal disomic plants. This tendency to produce extra univalent chromosomes through bivalent desynapsis depends to some extent on the particular chromosome present in the monosomic condition, on the environment under which the plants are grown, and on the backcross generation represented in the case of inter-varietal crosses involved in the chromosome substitution materials. The use of monoisosomic and monotelosomic stocks for backcrossing in a chromosome substitution program precludes difficulties from the above source, inasmuch as the aberrant chromosomes are readily distinguishable cytologically, and their use for a given chromosome provides no source of that normal chromosome from the recurrent Chinese Spring parent. There has been observed on occasion a tendency for the unpaired chromosome in monosomic materials to misdivide, giving rise to "telocentric" or onearmed chromosomes. Careful cytological study of plants to be used as parents has been found necessary both to establish clearly their chromosome constitution and to detect any aberrations in the chromosome being transferred in the chromosome substitutions. Three instances of aberration in the chromosome being transferred have been detected in the chromosome substitution materials to date. The fourth or third backcross generations for most of the 63 substitution lines for the three donor varieties noted above are being obtained in the greenhouse this Spring.

The initial F_1 crosses to the Chinese Spring monosomics have been completed for the additional donor varieties Lee and Frontana, for two additional Kenya selections, Kenya 58 and 117A, and for the Minnesota selections II-39-2 (Premier X Bobin²-Gaza), II-44-22 (Mida x Kenya 117A), II-44-65 (Timstein x Henry), and Minn. 2824 (Thatcher x

Surpresa). The first backcrosses to Chinese Spring have been obtained for approximately half of the chromosomes of each of these varieties and selections. The substitution lines for various of these possible donors will be obtained as time, space, and study of the substitution lines for the 3 principal donor varieties dictate.

The general plan for the inheritance studies being conducted includes tests of segregating F_2 populations from crosses between the variety to be studied and the complete set of Chinese Spring monosomics to locate the gene or genes for the disease reaction on specific chromosomes. Tests of F_2 and F_3 populations from the cross between normal (disomic) Chinese Spring and the variety are used to determine the number of genes and the type of gene interaction. Cytological identification of the monosomic materials is made either directly on the F_1 plants or on a small number of F_2 plants. Use of the latter technique makes it possible to select only those F_2 families with adequate seed for the disease tests. At least 100 F_3 lines from the normal cross are used for the "mode of inheritance" studies.

Some information has been obtained on the inheritance of stem rust resistance in Frontana to race 56 and also to race 15B. The first tests with an isolate of race 56 showed that the Frontana resistance was due to two dominant genes, the F_2 ratio being 15 resistant: 1 susceptible. Only part of the monosomics were available for testing, but chromosome VI clearly carried one of the factors. The other monosomic F_2 's were tested later with a different isolate of 56, but the other factor could not be located. A repeat test with F_2 and F_3 lines from the cross with normal Chinese showed that resistance to the isolate of 56 used in these latter tests was controlled by one dominant factor. Tests were then started with 5 isolates of race 56 from widely different locations in the United States in an attempt to locate one that would give the same reaction as the original isolate. F_3 lines with known behavior in the original tests were used. Only 3 isolates were finally tested, but none gave the reaction found in the original test. In tests in November, all of the Frontana monosomic F_2 's, plus a selection of F_3 lines were tested against 2 of the above race 56 isolates. The segregations obtained indicate one factor for resistance, but certain of the F_3 lines were resistant to one isolate, and segregated in reaction to the other. This indicates that the genes involved are probably different. The monosomic tests show in each instance that chromosome VI carries the factor for resistance. After these tests were completed, the plants were clipped and the new leaves inoculated with an isolate of race 15B. Under these ideal conditions in the greenhouse, Frontana was resistant to race 15B (1+ to 1++ reactions) and clearly different from the susceptible reaction of Chinese Spring. In this test the resistance of Frontana to 15B was recessive. Not enough F_3 lines were tested to determine the number of genes involved, but there are probably two or more with a complex interaction. None of the monosomic tests (including all but chromosome VI) gave all resistant plants as would be expected from a single factor. Several of the monosomic F_2 's gave an excess of resistant plants. These tests were run in narrow flats with two rows of 25 spaced plants to permit notes on individual plants. The readings for the two races

on the same plant showed, with few exceptions, that the plants resistant to 15B had also shown resistance to race 56.

A graduate student who has been assisting in the monosomic research is conducting an M.S. thesis research problem involving a similar study of stem rust race 15B resistance derived from Kenya Farmer, with a second test on the same plants to race 38. Final steps in the production of similar stocks for the study of inheritance of resistance to race 15B and other stem rust races derived from the Minnesota selection II-44-22 (Mida x Kenya 117A) are being completed this year. Tests of varieties resistant to races which are of increasing importance are planned also.

There are certain difficulties that must be resolved before the genetics of disease resistance in wheat can be put on a satisfactory basis. The first need is for the use of pathogen cultures derived from single spore isolates in genetic tests. Probably more important is the necessity of maintaining the same isolate of a given race for subsequent tests. A sufficient number of sub-cultures would have to be tested periodically to select against mutations or contaminations. Only if these procedures are followed can cultures of the organisms with known genetic factors for pathogenicity or virulence be established, and host genotypes with known genetic factors for disease reaction be isolated from the inheritance studies.

Sec. 2 - 10

The Inheritance of Resistance to Races 15B and 56 of Stem Rust in a number of Varieties of Common Wheat with Particular Reference to the Kenya Varieties.*

D. R. Knott

At the University of Saskatchewan a large scale program is underway to determine the inheritance and interrelationship of genes for rust resistance in common wheat. A standard procedure has been developed for use in these studies as outlined below:

1. The varieties under study are diallel crossed (Marquis and Thatcher are included in each group).
2. The F_1 and F_2 populations from the crosses are tested with races 15B and 56 in the greenhouse and with race 15B in the field.

* This work was supported by a grant from the Canada Department of Agriculture for Extra-mural Research Project EMR-16.

3. Each variety is backcrossed to the rust susceptible variety Marquis.
4. Up to 100 F₂ families from each backcross to Marquis are tested for seedling resistance to races 15B and 56 and representative families are tested in the field with race 15B.

Three groups of varieties have now been analyzed and the results are summarized in the two tables below. The first group was studied in conjunction with Dr. R. G. Anderson who submitted a portion of the work to the Field Husbandry Department as his Ph. D. thesis. In Table 1 the varieties and their probable genotypes are listed, using the system of gene nomenclature proposed by Ausemus *et al.* (J. Amer. Soc. Agron. 1946). The varieties are grouped according to the order in which they were studied. In Table 2 the genes and their modes of expression are given.

Table 1.- Varieties and their probable genotypes.

Variety	Genotype					
Kenya 58	$\frac{Sr_6Sr_6}{Sr_6Sr_6}$	$\frac{Sr_7Sr_7}{Sr_7Sr_7}$	$\frac{Sr_8Sr_8}{Sr_8Sr_8}$	$\frac{Sr_9Sr_9}{Sr_9Sr_9}$	$\frac{Sr_{10}Sr_{10}}{Sr_{10}Sr_{10}}$	
Red Egyptian	$\frac{Sr_6Sr_6}{Sr_6Sr_6}$	$\frac{Sr_7Sr_7}{Sr_7Sr_7}$		$\frac{Sr_9Sr_9}{Sr_9Sr_9}$	$\frac{Sr_{10}Sr_{10}}{Sr_{10}Sr_{10}}$	
Kenya 117A, C.I.13140		$\frac{Sr_7Sr_7}{Sr_7Sr_7}$		$\frac{Sr_9Sr_9}{Sr_9Sr_9}$	$\frac{Sr_{10}Sr_{10}}{Sr_{10}Sr_{10}}$	
Egypt Na 95		$\frac{Sr_7Sr_7}{Sr_7Sr_7}$		$\frac{Sr_9Sr_9}{Sr_9Sr_9}$	$\frac{Sr_{10}Sr_{10}}{Sr_{10}Sr_{10}}$	
McMurachy	$\frac{Sr_6Sr_6}{Sr_6Sr_6}$					
Gabo					$\frac{Sr_{11}Sr_{11}}{Sr_{11}Sr_{11}}$	$\frac{Sr_{12}Sr_{12}}{Sr_{12}Sr_{12}}$
Lee					$\frac{Sr_{11}Sr_{11}}{Sr_{11}Sr_{11}}$	$\frac{Sr_{12}Sr_{12}}{Sr_{12}Sr_{12}}$
Timstein					$\frac{Sr_{11}Sr_{11}}{Sr_{11}Sr_{11}}$	$\frac{Sr_{12}Sr_{12}}{Sr_{12}Sr_{12}}$
(Not true variety)					$\frac{Sr_{11}Sr_{11}}{Sr_{11}Sr_{11}}$	$\frac{Sr_{12}Sr_{12}}{Sr_{12}Sr_{12}}$
African No. 43	$\frac{Sr_6Sr_6}{Sr_6Sr_6}$	$\frac{Sr_7Sr_7}{Sr_7Sr_7}$				
Kenya C9906	$\frac{Sr_6Sr_6}{Sr_6Sr_6}$	$\frac{Sr_7Sr_7}{Sr_7Sr_7}$				
Kenya 338Ac.2.E.2		$\frac{Sr_7Sr_7}{Sr_7Sr_7}$		$\frac{Sr_9Sr_9}{Sr_9Sr_9}$	$\frac{Sr_{10}Sr_{10}}{Sr_{10}Sr_{10}}$	
Egypt Na 101		$\frac{Sr_7Sr_7}{Sr_7Sr_7}$				
(Kenya Governor)						
Veadeiro				$\frac{Sr_9Sr_9}{Sr_9Sr_9}$	$\frac{Sr_{10}Sr_{10}}{Sr_{10}Sr_{10}}$	
Red Egyptian type	$\frac{Sr_6Sr_6}{Sr_6Sr_6}$	$\frac{Sr_8Sr_8}{Sr_8Sr_8}$		$\frac{Sr_9Sr_9}{Sr_9Sr_9}$		
(P.I. 170910)						
Kenya B286		$\frac{Sr_7Sr_7}{Sr_7Sr_7}$			$\frac{Sr_{10}Sr_{10}}{Sr_{10}Sr_{10}}$	
Kenya 291 J.1.I.1	$\frac{Sr_6Sr_6}{Sr_6Sr_6}$	$\frac{Sr_7Sr_7}{Sr_7Sr_7}$			$\frac{Sr_{10}Sr_{10}}{Sr_{10}Sr_{10}}$	
Kenya 321 BT.1.B.1		$\frac{Sr_7Sr_7}{Sr_7Sr_7}$		$\frac{Sr_9Sr_9}{Sr_9Sr_9}$	$\frac{Sr_{10}Sr_{10}}{Sr_{10}Sr_{10}}$	
Kenya 350 AD.9.C.2	Sr Sr	$\frac{Sr_7Sr_7}{Sr_7Sr_7}$			$\frac{Sr_{10}Sr_{10}}{Sr_{10}Sr_{10}}$	**

* Veadeiro appears to have two additional genes for mature plant resistance to race 15B.

** Subject to confirmation.

Table 2.- Expression of individual genes for resistance.

Gene	Expression
<u>Sr</u> ₆	Conditions a fleck reaction to races 15B and 56 in seedlings. Resistance to race 56 is completely dominant but resistance to race 15B is dominant in some crosses but recessive in others (e.g. crosses with Marquis). Conditions fair resistance to both races in mature plants and is partially dominant. Homozygotes carry up to 20% rust with race 15B.
<u>Sr</u> ₇	Conditions a type 1-1+ reaction to race 15B and is partially dominant. A yellow chlorosis around pustules is typical even in heterozygotes. Conditions moderate resistance to race 15B in mature plants-homozygotes carry up to 30% rust.
<u>Sr</u> ₈	Conditions a type 2-2+ seedling reaction to races 15B and 56 and is partially dominant. Conditions only slight resistance to race 15B in mature plants. (The reaction of mature plants to race 56 is not known).
<u>Sr</u> ₉	Conditions a type 2-2+ seedling reaction to race 56 and is partially dominant. Effect in mature plants is not known.
<u>Sr</u> ₁₀	Conditions a type 1-1+ seedling reaction to race 56 and is partially dominant. (<u>Sr</u> ₁₀ appears to be a major modifier of the resistance to race 15B conditioned by <u>Sr</u> ₇).
<u>Sr</u> ₁₁ + <u>Sr</u> ₁₂	Complementary dominant genes conditioning a type 1+-2 seedling reaction to race 56. Complementary recessive genes conditioning moderate resistance to race 56 in mature plants.

Sec. 2 - 11

Stem-Rust Resistance in Four Varieties of Common Wheat

E. R. Sears and W. Q. Loegering
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At least ten different genes for seedling resistance to various races of black stem rust have been located on the chromosomes of the wheat varieties: Hope, Timstein, Thatcher, and Red Egyptian, collectively. Detection of these genes was largely made by tests of lines in

each of which a single chromosome from the resistant variety had been substituted for the corresponding chromosome of the variety Chinese. The 84 different substitutions had been accomplished by crossing and backcrossing to the Chinese nullisomics or monosomics for from 3 to 6 generations.

Each of the chromosomes listed in the accompanying table has been found to carry a gene (or genes) for resistance. In addition to these, there is evidently at least one more resistance gene in Hope, perhaps on chromosome IV. There is some evidence of minor genes on chromosomes II and IX of Thatcher.

Chinese itself may carry some resistance to race 111, on chromosome XI.

Chromosomes XIII and XIV of Timstein are responsible for the resistance of this variety to race 9 of leaf rust.

Reaction to various stem rust races of lines of wheat having the indicated chromosomes substituted in Chinese.

Chromosome	Reaction			Remarks
	Susceptible to:	Intermediate to:	Resistant to:	
Hope VIII	11,15B,32,36,44,59,111,125	17,38,49,56,59	19, 139	
Hope XVII	19,38,56,59		111	
Timstein X	15B		11,17,19,32,36,38,44,49,56,59,125,139	2 linked complement-ary dominants
Thatcher III	56	36	59, 111	Probably duplicate recessives
Thatcher XIII	56	36, 38	59, 111	
Thatcher XIX	11,15B,32,36,38,56,125		17,19,44,49,59,111,139	Dominant gene from Kanred (or Reliance)
Red Eg. VI	11,17,19,36	15B,32,38,44,49,56,59,125	139	
Red Eg. XIII	15B,38,49,59	17,56		
Red Eg. XX	15B,44,49,139	11,17,32,59,125	19,36,38,56	McMurachy gene, usually recessive

Note: The above tests were made over a period of years but always with the same culture of a given race.

Progress in the Transfer of Leaf and Stem Rust Resistance
from Agropyron elongatum (Host.) to Common Wheat.*

D. R. Knott

A stable $F_{1,3}$ wheat-Agropyron derivative, produced by Shebeski from the backcross (Chinese x Agropyron elongatum) x Chinese, was crossed and backcrossed a number of times to Thatcher. Both seedling and mature plant resistance to races 15B and 56 of stem rust proved to be dominant and each successive backcross was made on heterozygous resistant plants.

In the course of the backcrossing it was found that plants resistant to one race were resistant to both. In addition, plants resistant to stem rust were, almost without exception, resistant to leaf rust. Occasionally, however, plants appeared which were resistant to one rust and not to the other. When heterozygous resistant plants were both selfed and backcrossed to Thatcher, the frequency of resistant plants in each type of progeny was similar.

Cytological studies showed that the wheat-Agropyron derivative had 56 chromosomes and the F_1 plants from the cross with Thatcher had 49. The chromosome configurations at meiosis in the F_1 plants was highly variable. The number of univalents ranged from 6 to 11. Most cells had a tivalent and many had a quadrivalent as well. No cell having 21 bivalents was noted.

In the backcrosses to Thatcher the number of univalents decreased until resistant plants had a count of either $21_{II} + 1_I$ or $20_{II} + 2_I$. On selfing these plants rust resistant lines were obtained which carried either 21_{II} of wheat and 1_{II} of Agropyron chromosomes (addition lines) or 20_{II} of wheat and 1_{II} of Agropyron chromosomes (substitution lines). The derived lines were resistant to both leaf and stem rust and it is evident that resistance is carried on one Agropyron chromosome. Plants which were resistant to one rust but not to the other were found to carry a telocentric chromosome showing that the two resistances are on opposite chromosome arms.

The Agropyron chromosome does not seem to have any particularly deleterious effect on either plants or pollen. In fact in pollen the Agropyron chromosome seems to be able to substitute for a wheat chromosome.

In an attempt to transfer the Agropyron resistance to a wheat chromosome, plants having 21_{II} of wheat chromosomes + 1 Agropyron chromosome, were irradiated before meiosis. Pollen from irradiated heads was put on Thatcher. Some 1890 seeds were obtained, rust reactions were

* This work was supported by a grant from the Canada Department of Agriculture for Extra-mural Research Project EMR-16.

read on 1510 plants and 367 were resistant. Most of the resistant plants were studied cytologically and 21 plants in 12 progenies did not appear to carry the Agropyron chromosome.

Sec. 2 - 13

Cytogenetic Studies in Wheat and Wheat Relatives
R. C. McGinnis, Cereal Breeding Laboratory, Winnipeg, Canada.

With the continuous thread of new virulent races of rust becoming prevalent, there is an urgent need to make available in our breeding stock all possible new sources of rust resistance. Many of the wild grasses, closely related to wheat, have extremely good resistance to our present races of leaf and stem rust and a program is underway to exploit these sources as fully as possible.

A large collection of species of Aegilops, Agropyron, Haynaldia and Secale, as well as their wheat amphiploids, have been tested under stem and leaf rust epidemics. Attempts are being made to transfer their genes for rust resistance to Redman wheat. Thus far, the most promising new source of resistance appears to be carried in several Agropyron species. Amphiploids produced from wheat x Aegilops are generally not only less resistant but also prove to be quite sterile when crossed with Redman. Wheat-Agropyron derivatives, on the other hand, cross quite readily with Redman, and the high degree of resistance is more easily maintained.

At present, three Agropyron species are being used as rust resistant donors. These are as follows :

<u>Species</u>	<u>Derivative or Amphiploid</u>	<u>Chrom. No.</u>	<u>Source</u>
<u>A. elongatum</u>	Wheat x <u>A. elongatum</u>	2n=56	N.S.III-51-49 (North Dakota?)
<u>A. tricophorum</u>	<u>A. tricophorum</u> x <u>T. durum</u>	2n=56	Derivative 174 (Pullman, Wash.)
<u>A. obtusiusculum</u>	<u>T. durum</u> x <u>A. obtusiusculum</u>	2n=70	T.A. 326 (Cambridge, England)

The first mentioned derivative with A. elongatum has been used the most extensively thus far. Several plants with three doses of Redman are highly resistant to 15B₃ and similar in appearance and earliness to Redman. These plants vary in chromosome number from 42 to 45, a few having 21 pairs. In the plants having 21 pairs, it has not yet been definitely established whether this resistance is carried on a pair of Agropyron chromosomes or on a segment translocated to a wheat chromosome.

Seed of some of the early-generation, resistant plants was X-irradiated at 10,000 r to induce chromosome translocations. The chromosome number of the few resistant X₃ plants analyzed, varied from 41 to

43. It is hoped that a portion of an Agropyron chromosome carrying rust resistance has been translocated to a wheat chromosome.

Somewhat more difficulty has been encountered in the transfer of the resistance of A. tricophorum and A. obtusiusculum to Redman. Fertility is generally impaired in early generations. The resistance of the A. tricophorum x T. durum derivative has been maintained in a small F_3 population in a cross with Redman, although a limited backcrossing program met with no success. Further backcrosses to Redman should be more successful since the chromosome number is now more stable. The amphiploid, T. durum x A. obtusiusculum, has been crossed and backcrossed once to Redman. Only rarely is fertility achieved either from selfing or backcrossing. The chromosome number is still quite irregular. This amphiploid and crossed progeny have been immune to all races of rust tested and therefore it appears to be a very desirable source of resistance.

Sec. 2 - 14

Inheritance of Reaction to Stem Rust in Crosses Involving Frontana x Kenya 58-Newthatch as one of the Parents.

D. W. Sunderman, E. R. Ausemus, and K. J. Hsu

One of the main sources of resistance to stem rust race 15B and to leaf rust used in the Minnesota breeding program are three selections from the cross of Frontana crossed with Kenya 58-Newthatch N.S. No. II-50-17, II-50-18 and II-50-25. F_2 populations of N.S. II-50-25 crossed with Thatcher, Selkirk, and Rushmore were grown in the field in the 15B Nursery at St. Paul in 1955. The data are given in Table 1. Individual plants were classified to determine the number of factors controlling the reaction to race 15B. The rust epidemic was fair. While the material was grown under natural infection in the field, an artificial epidemic was created by the use of race 15B of stem rust in this nursery. Crosses between these three selections, II-50-17, 18 and 25, and each of these with Yaqui x Egypt-Timstein (PM3C53), N.S. No. III-54-8, gave only resistant F_2 plants in the field. This indicates that all four varieties have the same factor for field resistance to the biotype or biotypes of race 15B used in this study.

In the crosses of the three Frontana x Kenya 58-Newthatch selections crossed with Thatcher, Selkirk and Rushmore, the F_1 plants varied from T to 10 percent, with considerable variation within the same cross and between crosses.

The classification of the F_2 plants indicates that field reaction was controlled by two independent factors and that resistance

is partially dominant. This dominance seems to be influenced by certain modifying factors as shown by the difference in resistance of the F_1 plants from the different crosses and by the varying ratios in the F_2 . In backcrosses to the susceptible parent, segregates with a high type of resistance were easily obtained. A greater number of highly resistant F_2 plants were obtained when II-50-17 and II-50-25 were crossed with Rushmore than with the other crosses.

Leaf rust reaction in the field appeared to be controlled by a single factor and was recessive in all these crosses.

Another study of the F_2 field reaction and the seedling reaction of the F_3 lines in the greenhouse was made in a cross between N.S.No. II-50-17 and Rival. These data are given in Table 2. Based on the grouping of the classes, the field data indicate the reaction to be relatively simply inherited with perhaps a one or two factor difference. A calculated P value of .30-.50 was obtained for a goodness of fit ratio of 9:3:3:1. By using a different grouping an equally satisfactory fit can be obtained to a 3:1 ratio.

In seedling tests in the greenhouse, II-50-17 was resistant, showing a 0; reaction, while Rival was susceptible or type 4 infection. The results of these tests are given in Table 3. The data indicate two independent genetic factors control segregation in the F_3 lines. The P value of .30-.50 indicates a satisfactory fit.

Susceptible F_3 lines were obtained from moderately susceptible and susceptible F_2 plants in the field.

Table 1.- The mode of inheritance of factors controlling field resistance to stem rust race 15B in two selections of Frontana x K58-New-thatch in crosses with Thatcher, Rushmore and Selkirk.

Parent or Cross	Stem Rust Percent							Ratio	P.Value
	0	T	5	10	20	30	40		
II-50-17 Parent Thatcher "	22	3							
Selkirk						5	5		
II-50-17 x Thatcher F ₂	17	29	29	29	20	12	6		
II-50-17 x Selkirk F ₂	<u>21</u>	<u>26</u>	<u>7</u>	<u>10</u>	<u>11</u>	<u>6</u>	<u>7</u>	9:3:3:1	.20-.50
	129			39	49		13		
Thatcher ² x II-50-17 B ₁ F ₁ Grouping		<u>3</u>	<u>6</u>	<u>20</u>	<u>20</u>	<u>14</u>	<u>1</u>	1:1:1:1	.10-.20
		9		20	20	15			
II-50-17 Parent Rushmore "	12					5	9		
II-50-17 x Rushmore F ₁		1							
II-50-17 x Rushmore F ₂	<u>73</u>	<u>44</u>	<u>11</u>	<u>10</u>	<u>5</u>	<u>5</u>	<u>1</u>	12:3:1	.20-.50
Grouping	117		21			11			
II-50-25 Parent Selkirk "	12	1				4	6		
II-50-25 x Selkirk F ₁			1	1					
II-50-25 x Selkirk F ₂	<u>19</u>	<u>15</u>	<u>15</u>	<u>10</u>	<u>11</u>	<u>7</u>	<u>10</u>	9:3:3:1	.50-.95
Grouping	49			21		17	$\frac{6}{6}$		
II-50-25 Parent Rushmore "	10			8	2				
II-50-25 x Rushmore F ₁		1	2						
II-50-25 x Rushmore F ₂	<u>50</u>	<u>16</u>	<u>16</u>	<u>19</u>	<u>9</u>	<u>3</u>	<u>3</u>	3:1	.20-.50
Grouping		82			34				

Table 2.- Field Stem Rust Reaction of Parents and F₂ Plants, Greenhouse seedling reaction of F₃ lines derived from them and the proposed grouping of field rust classes for genetic study.

Parent or Cross	F ₂ field reaction		Grouping of field classes for genetic study		F ₃ seedling reaction		
	Pct. rust	No. plants	9:3:3:1	3:1	Number of Plants		
					Res.	Seg.	Sus.
II-50-17	0				2		
Rival	60S						2
II-50-17 x Rival	0	72			15	54	
	TR	21	111		1	19	1
	TSR	8				5	
	5R	10				10	
	5R-SR	3				2	
	5SR	18	39	150		18	
	10R	5				5	
	10SR	4				4	
	10SR-S	9				8	
	20SR	3				3	
	20SR-S	16	29			13	2
	30S-SR	4		46		3	1
	30S	6				4	2
	40S	4	17			3	1
	50S	7				4	2
	60S	6				4	1
Total		196	196	196	16	159	10

Table 3.- Chi-square Test for Goodness of Fit of Seedling Reaction of F₃ Lines Tested to a Culture of Stem Rust Race 15B.

Reaction class	Theoretical ratio	Observed No. of lines	Calculated No. of lines	P. Value
Resistant	1	16	11.563	
Segregating	14	159	161.88	
Susceptible	1	10	11.563	
Total	16	185	185.01	.30-.50

Progress and problems of breeding for rust resistance and other characters using the whole chromosome substitution method.

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Aneuploid lines have been developed in the hard red spring wheat variety Thatcher, and the soft white spring wheat variety Lemhi. Other studies have shown that the McMurachy gene for resistance to 15B is located on chromosome XX, and that two genes for stem rust resistance are located on chromosome X of the variety Timstein. The following substitution lines, (Thatcher) x Timstein, (Thatcher) x McMurachy, and (Lemhi) x Timstein and (Lemhi) XX McMurachy have been, or are being developed. During this past winter stem rust reaction of seedlings from seed plants that were monosomic for the representative substitution chromosome were studied.

The substitution line (Thatcher) IX Kharkov MC22 is being developed. Indications are that the line so developed will have winter growth habit. This problem is slowed up because derivatives that are monosomic for chromosome IX of Kharkov have winter habit of growth.

The substitution line (Thatcher) XVIII Prelude is over half completed. This line is developed with the objective of replacing chromosome XVIII of Thatcher with a chromosome that does not carry genes for winter habit of growth. Indications are that this line will be earlier than Thatcher.

Substitution lines of Lemhi chromosomes in Thatcher and Thatcher chromosomes in Lemhi are fairly well along.

I.- Leaf Rust Studies.

The Chinese Spring Thatcher Substitution Series were grown in the Rust Nursery at Winnipeg during the summers of 1954 and 1955. Following are the results that were obtained.

Chromosome Line or Variety	Leaf Rust 1954	Readings 1955
Thatcher	78	90
Chinese Spring	0.2	T
I	0.2	T
II	0.2	T
III	0.2	T
IV	0.2	T
V	0.2	T
VI	0.2	T
VII	0.2	T
VIII	0.2	T
IX	23.4	13
X	1.5	20
XI	0.2	T
XII	1.0	28
XIII	0.2	T
XV	0.2	T
XVI	0.2	T
XVII		T
XVIII	0.5	T
XIX	0.2	T
XX	0.2	T
XXI	26.3	25

As can be seen from these results, the difference in leaf rust reaction between the two varieties is conditioned by genes on chromosomes IX, X, XII and XXI. This is indicated by readings of higher than 1% infection for these chromosome lines in both years.

It is impossible on the basis of these results to draw any conclusions as to the mode of action of the genes involved.

II. Stem Rust

A. Transfer of chromosome XX of McMurachy to Thatcher and Lemhi.

(1) (Thatcher 5 McMurachy) XX McMurachy.

These plants, monosomic for chromosome XX, have had four backcrosses to Thatcher. Approximately 97% homozygous for Thatcher genes on the other 20 chromosomes.

(2) (Lemhi 6 McMurachy) XX McMurachy.

These plants, monosomic for XX of McMurachy, have had

five backcrosses to Lemhi, and should be approximately 98% homozygous for Lemhi genes on the other 20 chromosomes.

B. Transfer of chromosome X of Timstein to Thatcher and Lemhi.

(1) (Thatcher 9 Timstein) x Timstein.

These plants, monosomic for X Timstein, are homozygous (or nearly so) for Thatcher genes on the other 20 chromosomes since they have been backcrossed to Thatcher 8 times.

(2) (Lemhi 6 Timstein) X Timstein.

Monosomic for X Timstein, and approximately 98% homozygous for Lemhi genes on the other 20 chromosomes.

At present, the appropriate crossing programs are in progress to combine Thatcher substitution X and Thatcher substitution XX McMURACHY into a single line, that is a line of Thatcher having X Timstein and XX McMURACHY. A similar program with these chromosomes is in progress in the variety Lemhi.

Sec. 2 - 16

Inheritance of Resistance to Stem Rust.

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The following varieties were crossed in all combinations and the available progeny studied in F_1 , F_2 and F_3 for reaction to stem rust races 56 and 15B.

Kenya 122.D.1.T(L)	R.L. 1373
McMURACHY	
Gabo	
R.L. 2500	
Garnet	

The variety R.L. 2500 was received at this laboratory under the name of Timstein. However, investigations indicate that this variety is closely related to Gabo, and is not Timstein.

The Kenya and McMURACHY varieties again showed a single major gene in common for resistance to both races, as has been reported previously. The data indicated that Gabo and R.L. 2500 had at least one, and possibly two, genes in common for resistance to race 56. The rust resistance of these varieties was inherited independently of the

resistance of the Kenya and McMurachy varieties.

Many of the entries in the 1951 International Rust Nursery appeared outstanding for rust resistance in our plots at Winnipeg, Canada. Ninety-nine of these varieties were harvested and planted again in 1952, along with several Kenya varieties. Thirty-two of these varieties were used in crosses, giving 62 hybrid populations. It was hoped that a study of the F_2 generation under rust epidemic would provide an indication of any duplication of genes in different varieties, and would thus be useful in selecting the best available parents for our plant breeding program.

Sec. 2 - 17

Genetics of Resistance to Wheat Stem Rust.

A. T. Pugsley

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of Agriculture, Wagga, New South Wales, Australia.

With a view to securing more adequate information to guide wheat breeders in their improvement programmes a study has been made of several wheats from the World Wheat Collection.

Fifteen such wheats together with three others obtained from Kenya and Brazil were intercrossed and F_2 progenies inoculated with race 222 Anz 2 of Puccinia graminis tritici.

The results indicate that the following fifteen wheats possess a common gene for resistance designated Sr Ka 1:-

<u>Variety</u>	<u>1952 World Wheat entry</u>
Eureka	8
Kenya N.B.F6.K.G6.A.9(L)	21
Kenya R.F. 324	24
Kenya N.B.263 J(L)	25
Kenya 117.1.5.F(L)	26
Kenya 130 B.6.B	28
Kenya 117A	30
Kenya 122 D.I.T.(L)	31
Kenya 291 J.1.I.1	35
McMurachy	51
No. 43	66
Onas 52	279
Negroz 11-45	-
Kenya 58.F(L)1	-
Kenya 112A	-

The above series of wheats have been found to behave in a similar manner to oversea races. They are resistant to many races including 15B and are susceptible to race 49.

The three remaining varieties were shown to possess a different inherent resistance which is reflected in a differential behaviour to various physiologic races.

Sec. 2 - 18

"Inheritance of Reaction to Stem Rust in Certain
Durum and Emmer Wheats"

R. M. Heermann, Glenn S. Smith, L. W. Briggie
and E. A. Schwinghamer

The findings from a number of studies on inheritance of stem rust reaction in durum and emmer wheats will be summarized. Most of the results are from seedling tests with a composite of race 15B isolates.

Symbols have been suggested for the genes following a system similar to that proposed by Ausemus et al in the Journal of the American Society in 1946. The basic symbol for stem rust resistance is Sr. A numeral on the same level with the basic symbol indicates the locus. A subscript following the locus number indicates the variety in which the gene was found. A list of the varieties studied, genes found, suggested gene symbols and reactions to the races of rust used in the respective studies appears in Table 1.

In a Mindum x Vernal emmer cross a single dominant gene from Vernal emmer produced resistance to race 17 and a single dominant gene from Mindum produced resistance to race 147. These two genes were found to be allelic or very closely linked in repulsion. The Vernal emmer gene for seedling resistance to race 17 also produced adult resistance.

In studies with race 15B on Khapli emmer x Stewart, 2 dominant genes for resistance were found. One gene produces a type 1 reaction except under certain environmental conditions when a tendency toward a type 2 pustule is noted. The other gene produces a type X reaction with much necrosis surrounding the pustules. The presence of both genes produces the 1= reaction of Khapli emmer. The inheritance of adult reaction in this cross could not be accounted for with less than 4 factors. The 2 genes for seedling resistance are the same as or closely linked with 2 of the necessary genes for adult resistance.

C.I. 3255, P.I. 94701, R.L. 1714, and P.I. 168906 produce similar reactions with race 15B. For simplicity sake this reaction will be referred to as type 3-. The inheritance of seedling reaction from C.I. 3255, P.I. 94701 (C.I. 12898) and R.L. 1714 (C.I. 12924) was monofactorial in crosses with Stewart. Intercrosses among these varieties and P.I. 168906 indicated the genes from them were allelic. These genes condition both seedling and adult resistance.

St 464 and P.I. 192179 both were found to have 2 genes for resistance to race 15B. Again as in Khapli emmer one of these genes produced a type 1 reaction and the other produced a type with variable pustule size and pronounced necrosis. The two genes acting together produce a 0; type. These varieties appear to have the same or very similar genes for resistance. No segregation was observed in a cross between St 464 and P.I. 192179. Adult and seedling resistance were associated but there appeared to be additional factors which modified the adult expression of resistance.

The results from a cross between Khapli emmer and St 464 with race 15B indicated the necrosis producing genes from Khapli and St 464 are alike or allelic. The genes for the type 1 reaction from Khapli and St 464 were found to be non-allelic and independent of each other. Most of the F₃ progenies were homozygous for a 0; reaction, some of the progenies were homozygous for a 0; reaction, some of the progenies segregated for 0; and 1 or 3-type reaction, and a small number were homozygous for a type 1 reaction. No type 4 reaction was found at any time.

No segregation for adult reaction was obtained in the F₂ of intercrosses involving C.I. 7780, C.I. 7805, C.I. 8155, and St 464. All of these varieties are introductions from Ethiopia and appear to possess a common gene or genes for resistance to race 15B.

Table 1.- Summary of genes for stem rust resistance in durum and emmer varieties.

Variety	Gene symbol suggested	Seedling reaction with race			15B adult reaction	Origin
		15B	17	147		
Vernal emmer	Sr 1 _v		1-	4		Russia
Mindum	Sr 1 _m		4	1-		Minnesota
Khapli emmer	Sr 2 _k	X)			R)	India
	Sr 3 _k	1)			R)	
C.I. 3255	Sr 4 _t	3-			R	Tunisia
P.I. 94701 (C.I. 12898)	Sr 4 _p	3-			R	Palestine
R.L. 1714 (C.I. 12924)	Sr 4 _c	3-			R	Canada
P.I. 168906	Sr 4 _{mx}	3-			R	Mexico
St 464	Sr 2 _e	X)-0;)-HR	Ethiopia
	Sr 5 _e	1)				
P.I. 192179	Sr 2 _{pg}	X)-0;)-HR	Portugal
	Sr 5 _{pg}	1)				
C.I. 7780	Sr 2 _e)-0;)-HR	Ethiopia
C.I. 7805						
C.I. 8155	Sr 5 _e					

A Genetical Study of the Reactions of Certain Wheat Varieties to the Stem Rust Race 15B.

E. R. Ausemus, K. J. Hsu, D. W. Sunderman

Kenya Farmer and Minnesota II-50-18, a selection from the cross of Frontana x K58-Newthatch, are both resistant to stem rust race 15B. Triangular crosses were made between Minnesota II-50-18, Kenya Farmer, and a susceptible variety Ceres, to study the inheritance of reaction to this race. The parental materials, F_1 's and F_2 's were tested in the seedling stage to stem rust race 15B, under 75° - 76°F. in March, 1956. Minnesota II-50-18 gave a reaction of 0; , Kenya Farmer had "1" type, while Ceres was susceptible with 3 to 4 pustules.

The F_1 plants of II-50-18 x Kenya Farmer were all 0; . The F_2 population was classified as 153 plants as 0; and 11 plants with "1" type of pustule. The segregation fits a 15:1 ratio with a P value greater than 0.5. This indicates that II-50-18 and Kenya Farmer differ by two pairs of factors in their reaction to stem rust race 15B.

In the cross of Ceres x Kenya Farmer, the F_1 plants were as susceptible as Ceres. The F_2 population segregated into 78 susceptible plants and 79 resistant plants. The susceptible plants were 3 and 4's, while the resistant class contained plants which read 0; , 1, and 2. This segregation fits a 9:7 ratio, with a P value greater than 0.1. The difference between Ceres and Kenya Farmer in their reaction to 15B is thus attributed to two pair of factors.

In the cross of Ceres x II-50-18, the F_1 plants were as resistant as II-50-18. The F_2 plants were classified into two groups: a resistant group containing 196 plants reading 0; , 1, and 2, and a susceptible group composed of 33 plants classified as 3 and 4. The segregation when compared with a 13:3 ratio, gives a P value greater than 0.2. II-50-18 and Ceres seem to have two pairs of factors not in common.

To explain the experimental results, it must be assumed that II-50-18 has two pairs of factors, which condition the 0; reaction to 15B. Ceres has a pair of factors SS which conditions susceptibility, and is complementary to the resistant factors. The complementary effect of BS, however, is inhibited by A (or A is episatic to S). Thus, II-50-18 has the genotype AABBss, while Ceres is of the genotype aaBBSS. The genotype of Kenya Farmer could be aabbss, which conditions "1" type of reaction to 15B.

Another selection from the cross Frontana x K58-Newthatch, Minn. II-50-17, which is also highly resistant to 15B, has been crossed with the sister selection II-50-18. The F_1 plants are as resistant as both

parents, and in an F_2 population of 145 seedlings, no segregation has been found. It appears that II-50-17 and II-50-18 have similar factors as far as the reaction to 15B is concerned.

Ses. 2 - 20

Resistance to Stem Rust Race 15B by ionizing radiation in Wheat.

K. J. Hsu and E. R. Ausemus

Resistance to stem rust race 15B has been induced by irradiation in a spring wheat variety Lee. Dry seed lots of this variety were treated with X-ray dosages of 12,000 r and 16,000 r and with thermal neutrons at a dosage of approximately $9.94 \times 10^{12}/\text{cm}^2$ at Brookhaven National Laboratory in 1953. The X_1 , N_1 generation and the control were grown in the field at St. Paul, Minnesota. All of these were susceptible to stem rust race 15B. The X_2 , N_2 generation and the control were tested both at seedling stage in the greenhouse and at adult plant stage in the field. The frequency of X_2 or N_2 head progenies, which produced resistant segregates, as a percentage of the total progenies tested in each treatment was found to be 0.1% for X-ray irradiation at 12,000 r, 0.4% for X-ray irradiation at 16,000 r, and 0.4% for thermal neutron irradiation, whereas no resistant segregates were found in the progeny controls. A cytogenetic study of the nature of the induced changes is under way. The study includes among other things: (1) crosses between resistant lines obtained from X-ray and thermal neutron irradiation for studying the mode of inheritance of the induced resistance; (2) crosses between the induced resistant lines and several existing varieties resistant to stem rust race 15B to determine whether their resistance is due to similar or different genes, and (3) crosses of the induced resistant lines with monosomic and nullisomics to study the possibility of chromosomal aberration, and to locate any changes due to gene mutations. Increases of the resistant lines are being made at Brawley, California, during the winter of 1955-56, so that a yield trial and a quality test can be made during the summer of 1956.

In winter wheat, a new line, Minn. III-54-112, was irradiated with X-ray and thermal neutrons each at three different dosages. The experiment was made for the purpose of studying the effect of irradiation on winterhardiness, and other agronomical characteristics. The X_1 , N_1 , and the control have been planted during the winter of 1955-56 at St. Paul, Minnesota, in randomized blocks with five replicates for each treatment, including the control. Preliminary observations indicate that there are significant differences between treatments with respect to the number of seedlings emerged and also significant differences in the height of seedlings at 25 days of age.

Breeding for Stem Rust Resistance at the Institute of Technology of Monterrey.
Ings. Leonel Robles and Agustín Martín.

A wheat breeding program was established in 1949 at the Institute of Technology of Monterrey. Since that time more than 400 varieties and 8000 segregating lines have been studied. The objective of this program has been to develop high-yielding stem rust resistant varieties which are adapted to the irrigated lands of the State of Nuevo Leon.

The highest yielding varieties during the period from 1949 to 1954 together with their reactions to stem rust are shown in Table #1. Although stem rust was present every year in the nurseries, climatic conditions have been such that infection has been too light to adversely affect yield.

Stem rust races 139, 56 and 15B have been the most prevalent races in this region in recent years.

The commercial production of wheat in Nuevo Leon has increased greatly since these varieties were introduced.

Table No. 1.- Yield, Stem Rust Reaction and Maturity of the Five Highest Yielding Commercial Varieties in Nuevo Leon from 1950 - 1954.

Variety	Rust Reaction ⁺ and Yield in Kilos per Hectare										Average Yield in Kgs per Hectare 1950-1954	No. days to Matur ity
	1950	1951		1952		1953		1954				
	Rust	Yield	Rust	Yield	Rust	Yield	Rust	Yield	Rust	Yield		
Monterrey 64	-	1293	T	1528	R	1315	R	1122	MR	1839	1419	127
Monterrey 70	-	1513	T	1399	MR	2164	R	1211	MS	1932	1643	126
Gabo	-	2006	R	2176	R	1877	R	2615	MR	2442	2223	110
Kentana 48	-	1080	R	1463	R	1818	MR	2323	S	1692	1675	116
Yaqui 48	-	1253	R	733	R	1896	R	1840	R	1934	1538	105

+

R = Resistant
MR = Moderately Resistant
MS = Moderately Susceptible
S = Susceptible
T = Only Trace of Rust.

Variability in Resistance of Wheats to Stem Rust

Helen Hart

Minnesota Agriculture Experiment Station

Variability in the reaction of some wheat varieties and lines to a number of races of stem rust in different environments has been recognized for more than 25 years. With the present diversity of wheat lines and the recent changes in stem rust races prevalent in North America, more and more race-host combinations that are unstable over wide environmental ranges have been demonstrated.

Many different characters may contribute in varying degree to the resistance of a variety. Some, such as stomatal behavior and structural barriers that mechanically limit the rust, have been demonstrated previously; others may not yet be known or recognized. Several of these characters may contribute to adult-plant resistance.

The ease with which varieties become infected varies greatly, for some varieties have strict and narrow requirements with respect to moisture, temperature, and time needed for infection by certain rust races. A susceptible reaction in a variety does not always indicate that the variety is easily infected, nor does a hypersensitive reaction indicate that few infections will occur in a variety.

Even if easily and abundantly infected, the reaction of a given variety to a single rust race can vary greatly with the part and age of the plant affected and with temperature and other environmental factors. Some varieties are almost immune to certain races at moderate temperature, completely susceptible at fairly high temperature, and again almost immune at very high temperature. Much more work still needs to be done on the effect of temperature combined with other environmental factors.

Because of the great complexity and variability of numerous variety x rust-race combinations, it is not certain that varieties can be produced with physiologic resistance to all races. It is therefore desirable to develop varieties with as much generalized resistance or tolerance as possible. For the most rapid and certain progress in achieving this goal, it is necessary to learn and evaluate the individual characters concerned in this generalized resistance. Some varieties have at least some degree of this type of resistance. Attempts are now being made to determine the effective characters and to search for others. Once known, their degree of combinability can be ascertained and utilized in breeding for generalized resistance.

A Technique Which Has Been Useful in Classification of
Seedling and Adult Plants for Resistance to Stem Rust
Under Field Conditions.

Ing. Rubén Pérez, Alfredo Campos and N. E. Borlaug

In many varieties there is a poor correlation between rust reaction under greenhouse and field conditions. It has been necessary to develop a rapid and more efficient method for determining the rust resistance of lines in our backcross program, where we are in many cases making backcrosses on F_1 plants.

Our experience over the past three years indicates that a combination of seedling and field tests are desirable from a practical breeding viewpoint.

The method currently being used involves planting the advance backcross F_1 generation seed in paper cups in the greenhouse, with only 1 seed planted in each cup. As soon as the first two seedling leaves are sufficiently developed they are inoculated with the "tester stem rust race", which will permit the identification of factors contributed by the donor parent. As soon as the seedlings have been classified for seedling resistance the plants from each cross are divided into two groups. The seedling susceptible plants are transplanted into the field in one row and the seedling resistant plants into an adjacent separate row.

Good fertilization and irrigation practices are necessary both in the greenhouse and when transplanting is done into the field if well tillered plants are to be obtained. Seedlings should be inoculated as soon as possible and the seedling rust notes taken as soon as possible so that early transplanting to the field can be accomplished. If this procedure is followed and temperatures are not high when the seedlings are transplanted to the field, the seedlings suffer very little "shock", tiller profusely and develop into robust plants which permit good adult plant classification and also provide an abundance of F_2 seed.

When the plants in the "transplanted rows" begin to boot, they are inoculated by injecting a spore suspension of the tester race or races separately into each boot. Each inoculated culm is marked with a tag indicating the race employed and the date when the inoculations were made. This procedure permits the use of five or six different tester races on each plant if desirable.

Careful examination of the inside surface of the leaf sheaths of the inoculated culms from 3 to 4 weeks following inoculation will serve as a valuable guide to the plant reaction to any given race. The pustule type which develops on the inside surface of the leaf sheath of the inoculated culms are less influenced by adverse ecological conditions and therefore a better guide than those which may develop on the neck, glumes and awns of the spike which develops from inoculated

culms ("boots").

Additional information on relative susceptibility of plants and the spread of tester races can be obtained by applying light irrigations every 6 to 7 days, but this is not necessary if the pustule type on the inside of the leaf sheath is used as a primary guide in classification.

Sec. 3 - 1

Seedling Reaction of Wheat Varieties to Different
Physiologic Races of Leaf Rust.

C. O. Johnson.

The following table summarizes the studies which have been made at Kansas in recent years to determine the seedling reactions of nine winter and twelve spring wheat varieties to a large number of different leaf rust races. Most of these varieties are currently being used as parents in different breeding programs.

Seedling reaction to physiologic races of leaf rust of several wheat varieties that have been used as sources of resistance in breeding programs.

Variety	C.I. No.	Reaction of Wheat Varieties to races indicated			
		Highly Resistant	Moderately resistant	Intermediate	Susceptible
<u>Winter Wheats</u>					
Pawnee	11669	1,9,10,11,13,19,37,68,84,93		15	3,5,6,28,35,44,54,58,105,122,126
Ponca	12128	1,9,10,11,13,19,37,68,84,93	15		3,5,6,28,35,44,54,58,105,122,126
Concho	12517	1,5,6,9,10,13,15,19,35,54,93,122	3,37,84	11,58	6,11k,28,44,68,126
Mediterranean sel. 40		1,3,5,9,10,11,13,15,19,37,44,58,68,84,93,105,122	6,54,126		28
Westar sel.	13090	1,3,9,10,13,15,35,37,44,58,84,93,105,122,126	5,19,68		6,11,28

Variety	C.I. No.	Reaction of Wheat Varieties to races indicated			
		Highly Resistant	Moderately resistant	Intermediate	Susceptible
<u>Winter Wheats (continued)</u>					
Pawnee x C.I 12250	Several sels.	1,5,9,10,11,13,19, 35,37,54,58,84,83, 122	15	3,44,58	6,28,105, 126
Wabash x Am. Banner	12992	1,3,5,6,9,10,11,13, 15,19,28,37,44,58, 68,84,93,105,126		35	54,122
Wheat-A.elong. x Pawnee	several sels.	1,3,5,6,9,10,11,13, 15,19,35,37,58,105, 122			
(T.vulg.x T.ti- mo.)x Cheyenne	several sels.	1,9,10,11,13,19,37, 68	3,44,84	15	5,6,28,35, 54,58,105, 122,126
<u>Spring Wheats</u>					
Bowie	13146	1,3,6,9,10,11,13, 19,37,44,68,84,93	58	15,28,105	5,35,54,122 126
Chinese + Ae. umbellulata	several sels.	1,2,3,5,6,9,10,11, 13,15,19,20,28,35, 44,45,52,54,58,77, 93,105,122,126,131			
Kenya Farmer 338AC.2.E.2	12880	1,2,3,5,9,10,13,15, 19,20,35,58,84,93, 122	44		6,28,68,105 126
Lee	12488	1,3,5,9,10,13,15, 19,35,44,54,58,84, 93,122	11,37	6,68	105,126
Selkirk	13100	1,3,5,9,10,13,15, 19,35,54,58,84,93, 122,126	6,11c,28, 37,68,105		11k,44
Aniversario	12956	1,3,5,6,9,10,11,13, 15,19,20,28,35,37, 44,54,58,68,84,93, 105,122,126			
Renacimiento	12002	1,3,6,9,10,11,13, 15,19,37,44,58,68, 84,93,105	35,122,126		5
La Prevision 25	12956	1,3,9,11,35,44,54, 58,68,84,93,105,122	5,10,15,19, 28, 126	6,37	13
Sinvalocho	12545	1,9,10,11,13,19,37, 68,84,93			3,5,6,15,28 35,44,54,58 105,122,126

Reaction of Wheat Varieties to races indicated					
Variety	C.I. No.	Highly Resistant	Moderately resistant	Intermediate	Susceptible
<u>Spring Wheats (continued)</u>					
Frontana	12708	1,10,11c,15,28,58,68,84,93	3,6,11k,19,37,44,105,122	5,9,35,54,126	
Rio Negro	12469	1,10,11,15,28,58,68,84,93,122	3,5,6,9,13,19,37,44,105,126	35	
Gabo	11795	1,3,5,9,10,13,15,19,35,54,93,122	44,84,105	6,11c,37,58	11k,28,68,126

Sec. 3 - 2

Varietal tests to physiologic races of leaf
rust of wheat

A. M. Brown and T. Johnson

The testing of varieties to determine their reactions to particular physiologic races is complicated by the fact that many, perhaps all, races contain biotypes. The testing of a given variety against one or two cultures of a rust race does not necessarily determine the reaction of the variety to that race. Many cultures of each race are, therefore, kept available so that they can be either bulked or used individually in varietal tests. Resistant varieties important agronomically or as sources of resistance are used in "screening sets" in such a way that they are tested for their reaction to all leaf rust collections. These screening sets are subject annually to addition or deletion of varieties so that at any given time they contain varieties currently of interest for their leaf rust reaction.

Field and greenhouse tests indicate that the resistance of many South American varieties, including Frontana, Aniversario, Supremo, La Prevision, Colotana, Maria Escobar and Rio Negro, is adequate against the races now prevalent in Canada. Mida-McMurachy-Exchange II-47-26 has shown similar resistance. Resistance derived from Chinese appears to be adequate in the adult plant stage.

Sec. 3 - 3

Superior Resistant Reactions to Leaf Rust of Wheat from
Combinations of Resistances.

John F. Schafer, Ralph M. Caldwell, Leroy E. Compton, Fred L. Patterson
Purdue University Agricultural Experiment Station.

The short duration of the functional life of many rust resistant

grain varieties has been a major problem in the control of the rusts by the use of disease resistance. One of the several proposals suggested to increase the length of the functional life of future rust resistant varieties is to incorporate into the same genetic stock several resistance genes each one of which has a comprehensive race coverage. This would provide more than one physiologic barrier in each host plant against infection by the races involved. The theoretical advantage of this proposal is that simultaneous mutation or simultaneous combination of mutations for virulence to all of the resistances involved must occur within the rust population before a race capable of attacking such a variety could develop if the resistances are not also utilized singly. The frequency of such occurrence would be only a small fraction of the frequency of occurrence of virulence against single resistances. A major disadvantage is that once such a rust race is available, all of the resistances involved have been used up.

A technical problem in consummating this proposal is the determination of the presence of the combined resistances in one genetic stock because of their mutual coverage against races of rust. Such determination may be made by genetic analyses of progenies of crosses of susceptible varieties with several derived resistant lines or by pathologic techniques. Use of pathologic techniques is much simpler if they are available.

The wheat varieties, Aniversario C.I. 12578, Exchange C.I. 12635, Frontana C.I. 12470, and La Provision 25 C.I. 12596, all have a broad coverage of resistance against races of wheat leaf rust, Puccinia rubigo-vera tritici (Eriks.) Carleton. Their resistant reactions range from "0" types to some races to "1" and "2" or "x" types to other races. To develop a pathologic test to demonstrate the combination of parental resistance from these varieties, cultures of leaf rust races 76 and 89 have been used that give variations of a "1" or "2" or even a lightly mesothetic reaction on these varieties (Table 1). Apparently, true breeding F_4 or F_5 lines of 5 of the 6 possible paired hybrid combinations of these 4 varieties have been obtained which give a more highly resistant reaction than either parent, indicating a recombination of resistance genes from both parents. From the remaining combination F_2 plants superior to either parent in reaction to a culture of race 76² have been obtained. (See table 1).

Only rust cultures such as leaf rust races 76 and 89 which incite less resistant reactions than an immune type on the parental varieties can be used for this determination; however, other races should then be cross-checked to ascertain that the resistance of derived combined lines is at least equal to the parental types in relation to all races and cultures available.

It has not yet been determined whether this technique can be used for further recombinations of the derived lines. The final effectiveness of the genic combinations can be determined only by their wide usage in a commercial variety.

Table 1.- Reactions of 4 resistant wheat varieties and their paired hybrid combinations to races 76 and 89 of leaf rust, Puccinia rubigovera tritici. January, 1956

Variety or Hybrid No.	Parentage	Seedling Leaf Rust Reac. (1st and 2nd leaves)	
		Race 76	Race 89
Aniversario C.I.12578		1-	1 to 2
Exchange C.I.12635		1= to 1-	1 to 1+
Frontana C.I.12470		0 to X-	1-to 1
La Prevision 25 C.I.12596		1- to 1	2-
Purdue 52156R2-2-1	= Frontana x Exchange F ₄		0
" R2-2-5	= " "	0	
" 52157A1-9-3-1	= Aniversario x Frontana F ₅	0 to 1=	0 to 1=
" 52158A1-1-1	= " x Exchange F ₅		0 to 1=
" " A1-1-2	= " x "	0	
" 52159A1-2-1	= La Prevision 25 x Exchange F ₄	0 to 1=	0 to 1=
" " A4-3-1	= " x "		0 to 1-
" " A4-3-2	= " x "	0 to 1=	
" 52160A1-7-1	= La Prevision 25 x Aniversario F ₄		0 to 1=
" " A1-7-2	= " x "	0 to 1=	
" " A2-10-1	= " x "		0 to 1=
" " A2-10-2	= " x "	0 to 1=	
" " A4-4-1	= " x "	0 to 1=	0 to 1=
" 535A1-1 to A1-9	= " x Frontana F ₂	0 to 1=	

Sec. 3 - 4

Inheritance of leaf rust reaction among the eight differential varieties of wheat.

E. G. Heyne and C.O. Johnston.

The original plan was to study the segregating generations of the 28 possible crosses and of Pawnee crossed with the eight varieties and develop by backcrossing 8 lines of Pawnee with the genes of these 8 differential varieties. The latter has been changed to a backcross program to Wichita, which has been susceptible to all races of leaf rust for which it has been tested at Manhattan. All the determinations are made on primary leaves as difference have been obtained by reading the second leaf and adult plant reactions.

The data analyzed to date are only tentative and results of one season have not always checked with those from another. All segregating generations have been studied for reaction to race 9, many to race 5, some to race 15 and 126 and a few to race 11, 35, and 58.

Mediterranean, Democrat, and Pawnee probably have the same gene for reaction to race 9 and several other races for which they have been tested, as no segregation for leaf rust reaction occurred in F_2 or F_3 . Selecting homozygous resistant and susceptible lines from the cross Red Chief x Pawnee it was shown that the same factor governs resistance to races 9, 10, 11, 13, 19, 20, 31 and 93. It has been shown by monosomic analysis that the factor for resistance from Pawnee is located on Chromosome X. Mediterranean and Brevit probably have different alleles for reaction to race 9 as the F_3 generation segregated for reaction 0; to 2 but no susceptible type occurred. Hussar probably has a different non-allelic gene than Mediterranean and Democrat. Brevit and Carina probably have different alleles for resistance to race 9 while Loros and Webster are susceptible. In most cases there appears to be only one gene from any one variety for resistance to race 9 although in some crosses with Pawnee and Democrat more than one factor may have been involved. Resistance was partially dominant.

Brevit, Carina, Webster, and Loros probably have allelic genes for resistance to race 5 as two types of high resistance could be determined in segregating families. In the cross Mediterranean X Webster complete dominance of resistance from Webster to race 5 occurred—the only case of complete dominance observed in any of the crosses studied and races used. In some crosses Hussar appeared to have at least two factors for resistance to race 5 and in others only one. The variable response of Hussar from season to season may account for these differences. Crosses involving Carina as one parent also give segregates with variable results, such that in some crosses no satisfactory explanation of the data were possible.

In some crosses Malakof appeared to have two factors for resistance to race 15 and in others only one.

Brevit and Carina apparently have alleles for resistance to race 126. Webster is resistant to race 126 but probably has two non-allelic factors different than those of Brevit and Carina. These two factors may be linked.

With information secured from monosomic analysis the picture of genes for leaf rust reaction will become more clear. This method of analysis is also being used but no definite information has been secured.

Resistance to Leaf Rust Derived from Agropyron elongatum.

Ralph M. Caldwell, John F. Schafer, L. E. Compton, and F. L. Patterson

Plants of Agropyron elongatum were secured in 1935 from N. E. Hansen, of the South Dakota Experiment Station, who had introduced seed from Siberia. A number of typical soft red winter wheats have been obtained from Purdue cross number 39120 (Trumbull x Agropyron elongatum) F_1 x (Fultz x Trumbull-Hope-Hussar) F_1 . Additional crosses to vulgare wheats may have been involved in the parentage of the derived lines since outcrossing was obvious in the early generations. Field selection towards vulgare type and leaf and stem rust resistance has maintained a "0" type immunity to leaf rust races 1, 5, 9, 11, 15, 30, 31, 35, 45, 76, 80, 89, 126, 104 and 104B, and high resistance in the field or greenhouse to stem rust races 15B, 17, 38, 49, and 56. The derived lines have been stable in both plant type and rust resistance.

Backcrossed seedling plants (Purdue 39120A5-3-1-1-1 x Knox²) have segregated in approximate ratios of 1, immune to 1, susceptible, to leaf rust races 35 and 104B. Immunity to race 104B of two other derivatives of cross 39120 has segregated in a similar ratio in backcrosses to Knox (Table 1).

In F_2 seedlings of the cross, Knox sib x Purdue 39120A5-3-1-1-1, the leaf rust reaction to races 5, 76, 89, and 104B has segregated in approximate ratios of 1, immune to 1, susceptible (Table 2) The reaction to leaf rust races 5, 76, and 104B in mature F_2 plants. of the same cross has segregated in approximate ratios of 9, immune to 7, susceptible or intermediate (Knox reaction) (Table 2). F_3 seedling progenies of these mature plants have segregated in approximate ratios of 9, wholly immune or segregating to 7, susceptible. F_3 families in the immune and segregating classes were progenies of the immune mature plants while the families in the susceptible classes were progenies of mature plants of susceptible or intermediate reaction.

No genetic interpretation of these segregation ratios is apparent, and further work is in progress. This source of immunity is considered highly promising in the breeding program. Its dominance and complete coverage of all 15 leaf rust races tested makes it easy to work within the backcrossing program despite the difficulty of analysis. The leaf rust immunity of Purdue 39120A5-3-1-1-1, a stable vulgare type, has been transferred to the Knox variety through a series of 5 backcrosses.

Table 1.- Reaction of F_1 and BX plants to Leaf Rust

Hybrid	Leaf Rust Race	Generation	No. of plants	
			Immune	Susc.
Knox x 39120A5-3-1-1-1	104B	F_1	8	0
Knox ² x "	104B or 35	BX, F_1	68	80
Knox x 39120A4-2-1-2-3	104B	F_1	8	0
Knox ² x "	104B	BX, F_1	24	23
Knox x 39120A 4-2-2-2-2-2	104B	F_1	8	0
Knox ² x "	104B	BX, F_1	29	34

Table 2.- Segregation of Leaf Rust Reaction in the F_2 Generation.

Hybrid	Generation	Family	Leaf Rust Race	No. of plants		
				Immune	Susc.	
Seedlings						
Knox sib x 39120A5-3-1-1-1	F ₂	A1	76	79	82	
"	"	F ₂	A2	5	113	100
"	"	F ₂	A3	104B	107	110
"	"	F ₂	A4	89	105	106
Mature Plants						
"	"	F ₂	A ₁	104B	61	47
"	"	F ₂	A ₂	5,76,104B	63	43
"	"	F ₂	A ₂	104B	62	45

Stomatal Exclusion of Leaf Rust by Wheat Stems and Sheaths

Robert W. Romig and Ralph M. Caldwell

It has been generally observed that although the leaf blades of susceptible varieties become heavily infected with leaf rust, Puccinia rubigo-vera F. sp. tritici (Erikss. & Henn.) Carl., the leaf sheaths and culms are relatively free from infection in vigorous stages of development. However, as the plant ripens, the sheaths and culms may become infected. Greenhouse experiments with several varieties of wheat and three races of leaf rust have confirmed these observations. Inoculation of the inner epidermis of sheaths resulted in moderately abundant infection, indicating that resistance to normal infection through the outer epidermis was not due to internal or "protoplasmic" resistance.

A histological approach was used to explain this differential infection of plant parts. Epidermal strips were removed from the inoculated parts, fixed in absolute alcohol, and stained with fast green dye for microscopic examination of stomatal penetration by the fungus.

The ability of appressoria to effect penetration of the different parts was closely associated with the degree of infection. At anthesis the stomata of blades and of the inner epidermis of sheaths were readily penetrated. Low percentages of appressoria effected penetration of the outer epidermis of sheaths while peduncles were rarely penetrated. As plants ripened, high percentages of appressoria effected penetration of peduncles and the outer epidermis of sheaths. Penetration of dead peduncles also occurred readily. Abnormal lobing of appressoria and the formation of the infection apparatus on the surface were associated with resistance to penetration, since the parts with the lowest percentages of infection possessed the highest percentages of aberrant appressoria. Failure to effect penetration appeared to be the cause of this abnormal development of appressoria.

Peduncle injuries at anthesis resulted in infection adjacent to the injuries. The only plant character found to be associated with exclusion was the thicker walls of the stomatal cells of sheaths and peduncles. Since senescent peduncles and sheaths were readily penetrated, and infection occurred near injuries, stomatal function, as well as structure, may be involved in exclusion.

The Problem of Classifying Biotypes of Puccinia graminis var tritici and Other Cereal Rusts.

E. C. Stakman, D. M. Stewart, E. B. Hayden
U.S. Dept. of Agriculture and Minn. Agricultural Experimental Station.

It has long been evident from attempts to classify rust collect-

ions from or near barberry that the variety tritici of Puccinia graminis comprises an indefinite number of more or less freely interbreeding biotypes. Events of the past five years are evidence that many of these biotypes are likely to be widely distributed but undetected unless additional differential varieties of wheat can be found.

The problem is to classify the numerous biotypes of rust for scientific and practical purposes. The concept of races, as the term implies, was based on the assumption that it would be possible to arrange biotypes into somewhat natural groups or races by determining the infection types produced on representative wheat varieties, differential hosts, which are in reality biological indicators. It has long been assumed, and is now certain, that the adequacy of the grouping must depend upon the adequacy of the kind and number of differential wheat varieties that can be tested under appropriate conditions. Twelve varieties were long used as differentials, and continual search was made for others. Lee wheat has been added as a supplemental differential to distinguish sub-race 15B.

With the change in prevalence of races in North America since 1950, and with the great increase in number of new hybrid wheats, the classification of rust has become potentially more precise and actually more difficult. Whether the rust has actually become more complex in North America, or whether the complexities are only becoming more apparent, is not yet entirely clear, although both assumptions probably are true. It is clear, however, that some of the races now prevalent are so variable phenotypically that they can be identified definitely only at certain temperatures. This is conspicuously true of the 17-29 group, and the 49-139 group, which can be distinguished at moderate but not at high temperatures. Other environmental characters and combinations of characters also affect the phenotype of certain races on certain varieties; consequently there are two principal problems, (1) to devise ways of making a finer analysis of the biotypes within races, and (2) to find wheat varieties that are good differentials under a wide range of environmental conditions. The final problem of classification is, of course, one of grouping together those biotypes that have the most genes in common.

During the past several years, intensive search has been made for supplemental differential to distinguish sub-races. During the past two years, 32 varieties have been tested extensively for their suitability. Among them, the following are now known to be useful. For biotypes within the race 11-32 group: vulgare--N. Dak 3; durum--Ramsey (Ld 369) and R. L. 3206 (Canada). For the 17-29 group: vulgare--Magnif MG (Argentina); durum--Ramsey, C. I. 3255 (Spain); R. L. 3206, Tremez Molle (Portugal). For 15B: vulgare--K117A (C.I. 12568) and Magnif MG; durum--Yuma (Ld 364) and R. L. 3206. For 48A: vulgare--Magnif G (P.I. 197663) (Argentina) and Magnif Mg.

A system of classifying biotypes of rust must be usable. It appears now that finality in classification can hardly be attained, as there are numerous biotypes and new ones are continually arising in nature as a result of hybridization, mutation, and probably also as

the result of new nuclear associations in uredial mixtures. There undoubtedly are thousands of biotypes and a certain amount of "lumping" will be necessary in grouping them. The most feasible system will probably be to use a limited number of differentials for the first classification, into races; then to use others, if and when they are needed for distinguishing subraces; and finally to designate as known biotypes only thoroughly tested single-urediospore clones.

There must be better control of temperature and other environmental factors in identifying races. This will require different and more elaborate facilities than those now available at most places. Appropriate field tests of various kinds should supplement the work done in greenhouses or other types of plant houses. The principles apply in varying degree to P. graminis var. avenae and to other cereal rusts also.

Sec. 4 - 2

Races of Wheat Stem Rust in the United States and Mexico in 1955

Donald M. Stewart, E. C. Stakman, and R. U. Cotter

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In the United States, 28 races and biotypes or subraces were identified among 755 isolates from 574 uredial collections of wheat stem rust on wheat, barley, and grasses. Race 15B comprised 47 percent of the isolates; the 17-29 group 20 percent; race 56, 18 percent; 48A, 5 percent; and races 11, 38, and 59 comprised 2 percent, each. Other races were 1, 14, 15, 21, 23, 24, 29, 33, 35, 36, 38-40 group, 44, 81, 118, 122, 125, 139, and 186.

In Mexico, the 17-29 group comprised 63 percent of 191 isolates; race 15B, 18 percent; race 48A, 17 percent; and races 11, 38, and 56 were found once or twice each.

Although 15B is still the most prevalent race in the United States, it has decreased from the high of 63 percent in 1953 to 47 percent in 1955. It decreased in Mexico also, from 35 percent in 1953 to 18 percent in 1955. On the other hand, the race 17-29 (mostly 29) group increased in Mexico from 23 percent in 1953 to 34 percent in 1954 and 63 percent in 1955. In the United States, 17-29 increased from 4 percent in 1953 to 12 percent in 1954 and 20 percent in 1955. Race 48A was found in Mexico for the first time in 1953 when 2 percent of the isolates were of this race. In 1954 it comprised 31 percent of the Mexican isolates, but in 1955 only 17 percent. It increased slightly in the United States, comprising 5 percent of the isolates in 1955. The race 49-139 group decreases in Mexico from 17 percent in 1953 to 4 percent in 1954 and 0 in 1955. In the United States the 49-139 group comprised 1 percent of the isolates in 1953 but only 2 and 1 isolates were obtained in 1954 and 1955, respectively.

From 31 collections made from barberry in 7 States of the United States, 51 isolates comprised 25 races and biotypes, 18 of which were isolated only from or near barberry. Four of the 25 races mentioned above attack Vernal emmer. During the past three years a total of 42 races and biotypes have been isolated only from or near barberry.

Special attempt was made to identify a considerable number of collections made from barley and wild grasses, particularly in those areas where it is known that the wheat varieties are resistant to certain races. In 1955, however, the relative percentage of races obtained in this way was not essentially different from that in the United States as a whole.

During 1954 and 1955, special sets of varieties additional to the differentials were inoculated with selected samples of certain races that are difficult to identify certainly on the standard differentials. This was done in the hope of getting more precise information on some of the group-race complexes and to obtain indications of the possible value of certain varieties as additional differentials. Some progress was made, particularly in 1955, but the details will be given in a paper on the taxonomy of races.

Sec. 4 - 3

Wheat stem rust races in Canada in 1953, 1954 and 1955

G. J. Green and T. Johnson

In Canada, from 1953 to 1955, 20 races of wheat stem rust with 18 biotypes were identified. The biotypes were identified by supplementing the standard differential hosts with a group of accessory hosts consisting of wheat varieties that were of interest on account of their rust reactions or their economic importance. The predominant race was 15B (3 biotypes), which declined from 82 per cent of the isolates in 1953 to 66 per cent in 1955. In two of the three years race 56 (2 biotypes) was next in prevalence. Although this formerly predominant race declined to a low of 4 per cent of the isolates in 1954 it increased to 14 per cent in 1955. Other important or threatening races identified were: race 29 (4 biotypes); race 48 (2 biotypes); race 11 (2 biotypes); and race 87 (2 biotypes). These races occurred in Eastern and Western Canada except race 11 which became prevalent in Manitoba in 1955. The other races isolated were 1, 2, 10, 19, 34, 37, 38, 39, 59, 98, 113, 139 and 179. These races were uncommon and at present do not appear to threaten any important variety in Canada. With the exception of race 59 they were isolated from rust collections from provinces east of the Great Lakes and from British Columbia, the most westerly province. Spring wheat is not an important crop in these areas and rust is not an important production hazard. Most of Canada's wheat is produced in the Prairie Provinces of Manitoba, Saskatchewan and Alberta. It is here that rust is most damaging, especially in Manitoba and eastern

Saskatchewan. The biotypes are strains (or races) of rust within the races identified on the differential hosts selected by Stakman et al. As they have been differentiated by means of varieties which are being used as sources of resistance or on widely grown resistant varieties, they may be of considerable economic importance.

Sec. 4 - 4

Physiologic Races of *Puccinia Graminis Tritici*
Identified from Greece.

Rita Basile
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Rust collections were made during 1955 from wheat varieties growing in the plots of the Institute of Plant Breeding at Salonika, Greece. Although many of these collections arrived in Rome in poor condition three races were isolated. Race 16, which had previously been found only in Spain, was isolated from these collections. Race 34, which has been previously reported from Greece by Hassebrauk and Papavizas, was again isolated. A third race was also isolated from the variety Mara. This race does not appear to conform to any of the previously described races, and is herein referred to as race "N". Race "N" produces a reaction ranging from 1- to 1++ on all of the differential varieties with the exception of Arnautka and Khapli which both produce a 3= reaction (Table 1).

Reaction of Differential Varieties to Race "N"
of *Puccinia graminis tritici*.

Little Club	Mar- quis	Reli- ance	Arna- Kota	Spel- utka	Kub- Mindum	Eink- mar	Kub- anka	Eink- Acme	orn	Vernal	Khapli
1++	1++	1++	1++	3=	1++	1-	1+	1	1+	1++	3=

The physiologic races of stem rust which have now been identified from Greece includes 14, 21, 34, 40, 75, 16 and the new race "N".

The Physiologic Races of *Puccinia Graminis Tritici*
in Guatemala.

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Servicio Cooperativo Interamericano de Agricultura en Guatemala.

A historical review of wheat culture in the Republic indicates the crop was formerly grown in some areas where its culture has been abandoned in more recent times. There is considerable circumstantial evidence that it was grown commercially at elevations of as low as 2,500 feet shortly after its introduction. A hundred years ago there were extensive commercial plantings from 4000 to 5000 feet elevation. More recently the cultivation of this crop has been abandoned at these lower elevations largely because of the ravages of diseases, especially stem rust and root rots. Today the commercial plantings of wheat are confined to the cool temperature zone lying between 6500 and 10,000 feet, mostly located in the Northwest part of the Republic.

Experiments have been conducted in recent years, by the Servicio Cooperativo Interamericano de Agricultura wherein a large number of lines and varieties have been grown at elevations from 800 to 8000 feet. Repeatedly these experiments have shown that many of the varieties that are resistant to *Puccinia graminis tritici* at the higher elevations are very susceptible when grown at elevations of 6000 feet or less.

The difference in reaction was thought to be the result of: 1) different effect of environmental conditions, especially temperature, and 2) presence of different physiologic races in the different regions. In order to determine the relative importance of these two factors a study of the races which were present in the country was initiated in 1948(1). Table No. 1 indicates the races which have been isolated up to the present time. The first few years only relatively few collections were made and only a few races were identified. Collections made during 1953 and 1954 have resulted in the identification of a large number of races.

Table 1.- Races of *P. graminis tritici* isolated
from Guatemala.

Year	Race Isolated
1948	17, 49, 56
1949	17, 19
1951	17, 48
1953	17, 19, (17-29 complex), 24, 29, 28, 56, 85, 139, 142
1954	11, 15B (17-29 complex) 24A, 29, 56, (38-48 complex) 73, 139

(1) We wish to acknowledge the valuable assistance of personnel of the U.S.D.A. Federal Rust Laboratory and the Division of Plant Pathology of the University of Minnesota for the identification of the races herein reported.

When the rust collections were divided into two groups on the basis of the elevational zones in which they were made, the following race distribution was found:

<u>Altitude</u>	<u>Races Identified</u>
5000 feet or less	11, 15B, 24A, 29, 56,
7000 feet or more	11, 17, 19, (17-29) 224A, 29, 56, 73A, 85, 139, 142, 48, 49

All of the races found in the lower elevational zone with the exception of race 15B, were also found in the higher zone.

The relative prevalence of the races in 1954, based upon a study of 65 collections, is shown in Table 2.

Table 2.- Relative Prevalence of Races of *P. graminis tritici* in Guatemala in 1954.

<u>Race</u>	<u>Number of collections from which Race was isolated</u>	<u>Percent of Isolates</u>
11	33	50
24	11	16
15B	7	10
56	6	9
Others	8	12
Total number of collections studied	65	100

Conclusions:

1) The change in reaction of different wheat varieties to stem rust, when grown at different elevations is largely the result of change in the host-parasite interaction caused by differences in temperature, rather than differences in the race populations in the different elevational zones.

2) The rapid increase in number of races and the nature of the races which have recently been identified indicates that there probably exists an interchange of spores between Guatemala and other countries.

Sec. 4 - 6

Physiologic Races of *Puccinia graminis tritici* from Peru.

Ing. Rosendo Postigo, G. García Rada and M. Rondon.

A rust survey made in Peru during 1955 resulted in the identifi-

cation of 13 physiologic races of P. graminis tritici that had previously been described, and in addition 23 new races. These races were isolated from uredinal collections made from wheat, barley, rye, and wild grasses, and from aecial collections made from Berberis sp.

In descending order of prevalence the races were 15B, 189, 19, 14, 178, 17, 6, 24, 123, 11, 39, 53, and 115. The first six of the aforementioned races constituted 75 percent of the isolates, whereas the last six, as well as all the new races, were isolated only once each. Race 189 constituted 17 percent of the isolates and was found in nearly all areas where collections were made.

The addition of supplementary varieties to the set of differentials indicated that the races 189, 15B, 19 and 14 were each made up of more than one biotype.

The races isolated from Berberis sp. include 189, 19, 15B, 11 and two previously undescribed races.

Sec. 4 - 7

Physiologic Races of Puccinia graminis tritici and Puccinia rubigo vera tritici in the State of Rio Grande do Sul, Brazil

Ing. Mario Bastos Lagos and I. Schiehl.

A race survey was initiated in the wheat producing areas of southern Brazil in 1952, to determine the prevalence and distribution of rust races. The information herein reported covers the four year period from 1952 to 1955.

Puccinia rubigo-vera tritici is the most frequently encountered rust of wheat in southern Brazil, although it is generally much less destructive than stem rust. Stem rust occasionally reaches epidemic proportions and causes severe losses in some years.

Preliminary race identification studies conducted in 1941 by Vallega in Argentina, with rust collections from southern Brazil, established the presence of stem rust races 15, 17 and 42, of which 15 was the most prevalent. Race 11 was identified from Brazil by Silva and Lagos in 1950.

Vallega, Silva and Lagos have made irregular collections and identifications of leaf rust races from the four southernmost states of the Republic over the period of 1941 through 1952.

The results of the recent survey are summarized for stem rust in Tables 1, 2, 3 and 4. During this period race 17 constituted more than half of the isolates, with 15B being the second most prevalent race.

The isolates which were classified as race 17 were studied in

more detail employing 17 supplementary differential wheat varieties. These studies showed that the varieties Frontana, Colonias and Supremo 211 can be used to distinguish four biotypes of race 17 (Table 5).

The results of the leaf rust survey is summarized in Table 6. Physiologic race 20 is by far the most prevalent race constituting more than 50 percent of the isolates identified between 1952 and 1955.

Table No. 1.- Physiologic Races of *Puccinia graminis tritici* Isolated From Material Collected in Rio Grande do Sul during 1952.

Location	Frequency of Isolation			Total Number of Isolates Identified
	Race 11	Race 15B	Race 17	
Bagé	-	1	1	2
Erechim	2	-	2	4
Estrela	-	-	1	1
Julio de Castilhos	1	1	3	5
Palmeira	-	1	-	1
Passo Fundo	-	-	3	3
Pelotas	2	-	6	8
P. Alegre	1	1	1	3
Santa Rosa	-	1	-	1
Sao Borja	1	1	-	2
Sao Gabriel	-	1	2	3
Veranopolis	-	-	3	3
Total	7	7	22	36

Table No. 3.- Physiologic Races of *P. graminis tritici* Isolated from Material Collected in Rio Grande do Sul during 1955.

Location	Frequency of Isolation			Total number of Isolates Identified
	Race 11	Race 15B	Race 17	
Bagé	-	1	1	2
Cachoeira do Sul	-	-	1	1
Encruzilhada do Sul	-	5	9	14
P. Alegre	-	4	-	4
Veranopolis	1	-	-	1
Viamao	-	-	1	1
Total	1	10	12	23

Table No. 2.- Physiologic Races of *P. graminis tritici* Isolated From Material Collected in Rio Grande do Sul during 1953-54.

Location	Frequency of Isolation			Total Number of Isolates Identified
	Race 11	Race 15B	Race 17	
Canela	-	-	1	1
Cangucú	-	-	1	1
Cruz Alta	-	-	1	1
Encruzilhada do Sul	-	-	2	2
Erechim	-	-	1	1
Estrela	-	-	1	1
Julio de Castilhos	2	5	-	7
Passo Fundo	-	3	-	3
Pelotas	-	-	1	1
Piratini	-	-	1	1
P. Alegre	-	2	1	3
Rio Grande	-	-	1	1
Rio Pardo	-	1	1	2
Santo Angelo	1	-	1	2
Sao Borja	-	2	-	2
Viamao	-	-	3	3
Total	3	13	16	32

Table No. 4.- The Relative Prevalence of Stem Rust Races 11, 15B and 17 in Rio Grande do Sul from 1952 to 1955.

Year	Frequency of Isolation			Total Number of Isolates Identified
	Race 11	Race 15B	Race 17	
1952	7	7	22	36
1953 - 54	3	13	16	32
1955	1	10	12	23
Total	11	30	50	91

Table No. 5.- Reaction of Four Biotypes of Stem Rust Race 17 on Three Supplementary Differential Varieties.

Supplementary Variety	Biotype 17-A	Biotype 17-B	Biotype 17-C	Biotype 17-D
Frontana	4	2	3-	3
Colonias	2-	4	4	4
Supremo 211	4+	2++	2+	3

Table No. 6.- Physiologic Races of *Puccinia rubigo-vera tritici* Isolated from Collections Made in Rio Grande do Sul During Period 1952 - 55.

Location	Frequency of Isolation											Total No.
	Race 2	Race 13	Race 20	Race 31	Race 49	Race 57	Race 62	Race 77	Race 85	Race 108	Race 147	of Isol. Identif.
Bagé	-	-	2	-	-	-	-	-	-	-	-	2
Cacapava	-	-	3	-	-	-	-	-	-	-	-	3
Erechim	-	-	1	-	-	-	-	1	-	-	-	2
Estrela	-	-	1	-	-	-	-	-	-	-	-	1
Ijuí	1	-	-	-	-	-	-	-	-	-	-	1
Julio de Castilhos	-	-	1	-	-	-	-	-	-	-	-	1
Palmeira	-	-	-	-	-	1	-	-	-	-	-	1
Pelotas	4	3	6	-	1	-	-	-	1	-	-	15
Porto Alegre	2	-	6	-	-	-	2	2	-	-	-	12
Santa Rosa	-	-	-	-	-	-	-	1	-	-	-	1
Santo Angelo	-	1	1	-	-	-	-	-	-	-	-	2
Sao Borja	-	-	1	-	-	-	-	-	-	-	1	2
Veranopolis	-	-	1	1	-	1	-	-	-	1	-	4
Total	7	4	23	1	1	2	2	4	1	1	1	47
Race Group	2	9	9	9	9	45	2	21	12	9	9	

Sec. 4 - 8

Pathogenicity Characteristics of a Biotype of 15B of *P. graminis tritici* from Ecuador.

José Vallega and Hugo Cenóz.

During 1955 the authors, while visiting Ecuador, made twenty uredinal collections of *P. graminis tritici* at the Agricultural Exper-

imental Stations at Conocoto and Izobamba in the vicinity of Quito.

Subsequent identification employing the conventional differential varieties, as well as many supplementary differential varieties which have been used by investigators in other countries, showed all of these collections to be of a single biotype of race 15B. The only described biotype of 15B with similar pathogenic characteristics is that described and designated 15B-4P by E. Rojas M. in Peru.

The biotype isolated from Ecuadorian material and described below (Table No. 1) is of extraordinary potential importance to Argentina because of its ability to attack Mentana and its derivatives and other new Argentine varieties. The new variety Castelar Magnif 27 (synonymous with Magnif MG), which heretofore has shown outstanding resistance to all stem rust races and biotypes which have been isolated from the wheat growing countries of southern South America, is alarmingly susceptible to this biotype.

Table No. 1.- Reaction of Differential and Supplementary Varieties of Wheat to a Biotype of Race 15B of P. graminis tritici Isolated from Ecuador.

<u>D.I.V.*</u>	<u>Variety</u>	<u>C. I.</u>	<u>Reaction Type</u>
5417	Little Club	4066	4
15	Marquis	3641	4
26	Reliance	7370	4
17	Kota	5878	4 +
18	Arnautka	1493	4
19	Mindum	5296	4
20	Spelmar	6236	4
21	Kubanka	1440	4
22	Acme	5284	4
23	Einkorn	2433	4 +
24	Vernal	3686	4
25	Khapli	4013	0; a 1
5209	Lee	12488	4
2100	Hope	8178	4
7141	Farmer		0; a 1-
4743	Mentana		4 +
7636	Selkirk	13100	4
7201	Bowie	13146	0; 3=
7130	Etiopia	7905	0;
236	Egypt NA	95	0; 2-
1391	Golden	6227	4
2432	Timopheevi	11802	4
5066	Magnif G		3 to 4
5644	Baladi 116	7265-5	0; 3-
7600	Magnif MG		3 to 4

* Argentina Dept. of Agriculture Collection Number.

Some Aspects of the Taxonomy of Race 15B of Puccinia
graminis tritici in Peru.

Ing. Emilio Rojas M.

Four biotypes of 15B have been identified in Peru. One of these commonly referred to as 15B-2P (and known in other countries as race 189) is especially virulent on many wheat varieties. The four biotypes of 15B can be clearly distinguished from one another by their reaction on the wheat varieties Khapli, P.I. 60599 (Var. # 11) and Mentana as is shown in Table No. 1. Fortunately lines and varieties have been found in the breeding program with moderately good seedling resistance to all four biotypes under greenhouse condition, and good adult plant resistance under field conditions.

Biotype 15B - 1P is found only on the Coast, whereas the three other biotypes are found throughout the wheat growing areas of the Sierra de los Andes. Biotype 15B -2P (189) although principally distributed in the Sierra has become more common in the wheat growing areas of the northern coastal region since 1955. Race 189 was originally identified from the same area in 1939 and 1940.

Collections of Aecia from Berberis sp. made in Andahuaylas at an elevation of 3500 meters have produced infection on wheat seedlings. Biotypes 15B-2P (189), 15B-3P and 15B-4P have all been isolated from aecial collections.

Table No. 1.- Reaction of Three Varieties of Wheat to
Four Peruvian Biotypes of Race 15B of
P. graminis tritici.

Reaction of Varieties			
Peruvian Biotypes of 15 B	Mentana	Variety # 11 (P.I. 60599)	Khapli
15B -1P	R	S	R
15B -2P (189)	R	R	S
15B -3P	R	R	R
15B -4P	S	R	R

The lines which have shown good to moderate resistance to all biotypes of 15B as well as to the other races of P. graminis tritici which are prevalent in Peru are listed in Table No. 2.

Table No. 2.- Lines With Resistance to Biotypes of 15B and to other Races of P. graminis tritici which are Prevalent in Peru.

Selection No.	Cross	Reaction to Race 189 (15B-2P)
2 - 52	Maria Escobar ² - Kenya 58	2-
18 - 52	Klein 40c, 9606 x Kenya 58	2-
29 - 52	Garnet x Kenya 58	2-
63 - 53	Reward - H 44 x Rhodesian C 12273	2+
104 - 53	Maria Escobar x H44-Marquis C.I.11782	2++, 3=
84 - 52	Maria Escobar x A.V. 18/1.1.1.1.1	2-

A new variety Helvia derived from the cross, Maria Escobar x H44-Marquis C.I. 11782, with resistance to the biotypes of 15B is now being distributed to farmers.

Sec. 4 - 10

Progress Report on Genetical Analysis of Pathogenicity
in some Rust Pathogens.

J. G. Dickson

Investigations on the genetics of pathogenicity in 3 rust fungi and methods for evaluating their potential specialization in pathogenicity are reported. Flor, working with flax rust has demonstrated the gene control of pathogenicity in this fungus. Methods used in the present investigations involved the analysis of genes for pathogenicity in collections of the pathogen by the use of host differentials with specific genes or gene groups conditioning rust reaction. Urediospore clonal lines were used first to evaluate heterogeneity of the population and determine biotypes present. Clonal lines apparently uniform in reaction were then inbred through the aecial host and reanalyzed for reaction to specific genes conditioning rust reaction in the host.

1.- Preliminary investigations with Puccinia graminis tritici. Unfortunately most of the wheat genes conditioning reaction to stem rust were not available in readily usable form for detailed studies of this nature, therefore, the reaction of clonal lines of 3 physiological races

were evaluated only on Minhardi, Ceres, Thatcher and Kenya Farmer. Uredial clonal lines of races 56, 15B and 49 were increased on Minhardi and compared for specificity in reaction on the 4 wheat varieties. Population studies through 3 generations indicated uniformity in reaction between 165 lines from 56 and variation in reaction between 42 lines from 15B and 45 clonal lines of 49.

2.- Analysis of specialized races of Puccinia graminis avenae. Investigations by Welsh and Johnson have shown a regrouping of physiological races of this pathogen on the basis of reaction to specific genes or gene groups in oats. Urediospore clonal lines of 1, 2, and 3 races in each of 5 race-groups differentiated by Richland, Rodney, Garry, Clintland, and Roxton have been analyzed for reaction and teliospores produced for inbreeding through the aecial host, Berberis. These races appeared more uniform in reaction than the limited number of tritici studied.

3.- Production of apparently homozygous biotype races of Puccinia sorghi. Clonal lines of physiological races designated 1, 2 and 3 were differentiated using 9 inbred lines of maize; 8 with single dominant gene pairs conditioning differential resistance and 1 homozygous susceptible to all 3. The clonal lines were inbred through the aecial host, Oxalis, and single aeciospore populations increased on 2 homozygous susceptible maize lines and reanalyzed for rust reaction on the differentials. Biotype race 1 was avirulent for all 8 genes conditioning resistance and virulent on the homozygous susceptible inbred, 2 was virulent for 1 gene of the differentials, and 3 was virulent for 2 genes. Further inbreeding and hybridizing to determine the geneic basis of specialization are in progress.

4.- Special techniques found useful. Plant growth chambers with 16 hours light (2000 foot candles) and temperature 60-65°F during dark period resulted in maximum urediospore production and early teliospore formation. Short lengths of horse hair are used for transfer of single spores. A small piece of $\frac{1}{2}$ percent water-agar is placed on the leaf to locate spore and to supply moisture.

Sec. 4 - 11

Tests on the reaction of wheat varieties to stem rust races.

G. J. Green and T. Johnson

The testing of varieties for their reaction to specific races is complicated by heterogeneity in some varieties, by the presence of biotypes in some races and by the fact that the reaction of many varieties is influenced by temperature. In Selkirk wheat, the 42 foundation lines are all resistant to the common type of race 15B at low and moderate temperatures but are susceptible at high temperatures. To certain races (e.g., 56 and 139) about half the lines are resistant at both low and high temperatures while the other lines are susceptible at high

temperatures. The lines susceptible to ordinary race 56 at high temperatures are susceptible to the biotype 56A even at low temperatures.

Biotypes have been found in race 29 which produce moderately heavy infection on K117A, K321B.T.1.B.1 and K360H in the seedling stage. In view of the presence of biotypes in this and other known races it seems advisable to include any rust resistant varieties that are of particular interest in "screening sets" that are tested for varietal reaction to all the rust collections studied rather than to test the reactions of such varieties only to select specimens of each race. No races or biotypes have yet been found that are virulent to Kenya Farmer or Mayo 54.

Tests with durum varieties have shown that the Canadian variety D.T.136 is moderately susceptible to the biotype of race 15B that attacks Golden Ball and is also susceptible to a biotype of race 11 and certain biotypes of races 29 and 48. D.T.137 is not pure for rust reaction. It contains a proportion of plants susceptible to the above races. Of the new American varieties Yuma was resistant to all races to which it was tested; Ramsey and Towner showed some susceptibility to the biotype of race 15B that attacks Golden Ball, while Langdon was susceptible to that biotype and the biotype that attacks Selkirk.

Sec. 4 - 12

Physiologic Races of *Puccinia Graminis Tritici* Collected From
Wheat Near Barberry Bushes.

E.C. Stakman, W.Q. Loegering, D.M. Stewart, W.M. Watson
and C.W. Roane.

U. S. Department of Agriculture, and Virginia Agricultural
Experiment Station.

The diversity of races of *Puccinia graminis tritici* originating from barberry is well known although the natural survival value of these races on susceptible wheat has not been reported. This study is an attempt to determine the races of *P. graminis* which become established on wheat from aecial inoculum, and to determine the survival value of these races in subsequent uredial reproduction on susceptible wheat. From 1950 to 1953, four wheat fields next to barberry bushes in Wythe County, Virginia, were sampled. Rust was collected on two dates from the fields such that the primary and the ultimate uredial inoculum were sampled. From these fields 42 races and biotypes were isolated, 29 in 1950, 15 in 1951, 16 in 1952, and 9 in 1953. Twelve of the races were not found elsewhere in the United States during the same period. Races 15 and biotypes, 23 and biotypes, 38, 56, and 59 and biotypes predominated. Race 59 and its biotypes tended to arise from barberries in large numbers and become less dominant as the season progressed. Race 56, the only one to be collected from all four fields, tended to dominate at the end of the season. Many

racess originated on barberry bushes, produced uredia on wheat, but apparently failed to spread and were not detected in the second collections. A few races were detected only in the second collections. There is evidence that many races are produced on barberry, some of which become the dominating races on susceptible wheat, others of which do not become epidemic even on susceptible varieties. It is obvious that differences in environment from year to year will influence the ultimate composition of the mixture.

Sec. 5 - 1

Changes in the Prevalence and Distribution of Physiologic Races of Puccinia rubigo-vera tritici in the United States.

C. O. Johnston.

There have been significant changes in the prevalence and distribution of physiologic races of Puccinia rubigo-vera tritici in the United States during the past 20 years. These changes seem to be related to changes in varieties of wheat. UN5 has become the most abundant race in the United States, especially in the hard red winter wheat area where Pawnee is the most widely grown variety. UN6 now is increasing in the same area, where Ponca, Westar, Concho, and Bowie have been distributed recently or have been grown extensively in experimental sowings. UN10 containing race 11, long the dominant race on the Pacific coast and in Mexico, is slowly increasing in the Southeastern and Northeastern States. UN13 containing the virulent races 35, 54, and 122 is increasing rapidly, especially in Southeastern states where Chancellor has become an important variety. UN11 (race 93) has been found frequently in Southeastern states in recent years but seldom has been found elsewhere.

Sec. 5 - 2

Physiologic Races of Wheat Leaf Rust in Canada in 1953, 1954 and 1955

T. Johnson, A. M. Brown and G. J. Green

For purposes of studies of race distribution, the agricultural area of Canada comprises three distinct regions: Eastern Canada, from Lake Superior eastwards; the Prairie Provinces, Manitoba, Saskatchewan and Alberta; and British Columbia. From 1953 to 1955, race 58 predominated in Eastern Canada, as in earlier years. In the Prairie Provinces, races 5, 15 and 126 were predominant. In British Columbia races 1, 9 and 11 occurred frequently. Several races, particularly 1, 5, 15 and 126 may be divided into biotypes that differ in virulence on derivatives of Hope and H44. The variety Renown has been used as an accessory host to distinguish between these biotypes. During 1953-1955 the most virulent

biotypes made up 91.5 per cent of the isolates in the Prairie Provinces, 20.6 percent in Eastern Canada and 26.0 percent in British Columbia. It is believed that the concentration of these biotypes in the Prairie Provinces is the result of the widespread growing of Hope and H44 derivatives in that area and the adjacent United States. Some evidence has accumulated that races 11, 15 and 126 contain biotypes differing in virulence on the variety Lee.

Sec. 5 - 3

Pathogenicity of Puccinia rubigo-vera agropyri on Cereals.

C. Sibilis

Stazione di Patologia Vegetale, Rome, Italy.

The aecial stage of Puccinia rubigo-vera agropyri (ERIKSS) Arthur, is frequently found in Italy on the leaves and leaf branches of *Clematis vitalba* L. Aeciospores from this host have been induced to create infections on the leaves of seedlings of wheat, barley, and rye under greenhouse conditions. This seems of special interest because in the literature only a slight mention has been found concerning the relationship of this parasite to these hosts.

The inoculation tests referred to above were repeated several times when the greenhouse temperatures varied between 19° and 22°C, and in all cases similar results have been obtained. Mentana wheat seedlings inoculated with aeciospores have invariably produced type 4 pustules. The inoculation of barley seedlings resulted in a reduction in the number of pustules per leaf, as compared with similar inoculation on wheat, and the reaction was a type 2 pustule. Inoculations on rye seedlings produced only flecks (;). Inoculated oat seedlings remained free of infection in all cases.

The results of these inoculations suggest that Puccinia rubigo-vera agropyri may be considered an occasional parasite of wheat in nature, even though up to the present time it has not been found infecting this plant under field conditions.

Sec. 6 - 1

Field Surveys and the Estimation of Rust Losses.

D. G. Fletcher

Estimating damages caused by plant diseases, and particularly losses due to rust, is far from an exact science. Nevertheless, reasonably accurate data on crop losses are useful in pointing out needs for particular lines of research in the plant sciences; guide operation of many control and regulatory programs; and increase in the effectiveness

of agricultural extension and crop insurance programs.

The interaction of the many factors which affect growth of the host plant, growth of the disease or insect pest, and effect the interaction of the two, determines the extent of the damage which occurs. As a result, the development of precise formulæ with which to predict the degree of loss has been impossible thus far. The accuracy of loss estimates has depended largely on the judgment of the person or persons interpreting the situation. Guides, yardsticks, or rules of thumb although useful as standards of comparison in analyzing crop loss situations, vary with the crop, geographical location and the disease, insect pest or other condition responsible for abnormal growth of the crop.

The observer can develop a sounder basis for making observations and estimating losses by familiarizing himself with the long-time performance of crop plants, the diseases that attack them, and the effect of climate, soil and cultural practices on their severity in the region being considered. It should be realized that even in regions where surveys of plant disease and insect pests have been made for many years, the uniformity, coverage and accuracy of such records oftentimes leaves much to be desired.

Accurate field observations, which cover the main producing areas of the crops concerned, are of utmost importance. Adequate sampling and at least two field trips (one just before harvest) are the minimum requirements. Well distributed key fields should receive careful study on repeated visits. Careful records of location, date, condition of crop, stage of development, prevalence and severity of diseases and insects, soil moisture, temperatures, etc., must be consistently recorded. Hand-threshed samples of grains approaching maturity are often very revealing.

A careful study of the harvested crops, in the farmers' bins, commercial storage, and in the hands of the processor will add information to the study of the total loss incurred. Quality as effected during production is reflected by grade, test weight, food and feed value, protein quality and quantity, and yield of processed product (such as flour from grain). The loss of quality due to diseases and insect pests results in lower prices to the producer. This dollar loss should be added to the dollar loss due to decreased yield when final loss figures are prepared.

In view of the importance of the human factor in measuring crop losses, it seems obvious that to argue about small differences of opinion is absurd. If an experienced observer can estimate within 10% of the actual loss for a particular field before harvest, he is an unusual person. Over large regions containing several states, when losses are heavy, differences of opinion between qualified observers may be from 5 to 10%. This is especially true when damage varies considerably between fields and areas of production. When losses are light, a difference of from 1 to 3% is well within the margin of error. In the writer's opinion, losses of less than 1% should be recorded at

a trace.

Research to determine the potential production of a crop under varying and controlled conditions of temperature, humidity, light, fertilization practices, and soil type would be extremely helpful to crop observers in increasing the accuracy of loss estimates. Precise information regarding the quantitative effect on yield of time and severity of attack by disease or insect pests under varying environmental conditions would be helpful. The use of chemicals or disease-resistant isogenic lines to isolate the effects of diseases on yields might be useful in separating the many components affecting yields.

As our knowledge and proficiency in recognizing, correlating and evaluating the many factors involved in determining crop losses improves, it is probable that forecasting in this field may become still more useful. Should systemic chemicals having therapeutant value become widely applied, accurate field surveys to determine the incidence, development, and spread of plant diseases correlated with meteorological conditions would be imperative to the economic and successful application of such agents.

Sec. 6 - 2

Barberry Eradication in the United States.

R. O. Bulger.

Plant Pest Control Branch, ARS, U.S.D.A.,
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Barberry eradication in the United States is a cooperative effort of state, county, and Federal governments, and of individuals and organizations. More than 495 million rust-susceptible bushes have been destroyed on 149,318 rural, city, and urban properties in the 19 cooperative states. Approximately 90% of the area has been worked initially and about 30% has been reworked one or more times. To accomplish these results it was necessary to inspect 2 1/2 million farm properties and millions of city and urban properties. There remain 70,524 miles to be worked one or more times in the future.

The interstate movement of barberry, mahoberberis, and mahonia plants is regulated by Federal Quarantine and the intrastate movement by State Quarantine. During 1955, Federal personnel inspected 427 nurseries and 74 dealers with an inventory of nearly 18 million plants. Of the approximately 200 species and so-called varieties of barbaries, mahonia, and mahoberberis in the United States, 63 have been found to be resistant to the stem rust fungus.

Several herbicides are effective in killing barberry. Berberis fendleri, is killed with a low volatile ester of 2,4-D used as a fol-

iage spray with water as a diluent. Oil is used for dormant spraying during the fall and winter months. Brush Killer 32-P (2 parts 2,4-D and 1 part 2,4,5-T plus pentachlorophenol) with oil as a diluent is effective on B. canadensis. Oil solutions of MCP (2 menthyl-4 chlorophenoxyacetic acid) and Brush Killer 32-P have given equally good results in killing B. vulgaris. Ammonium sulfamate applied to cutoff canes at the ground level is used for killing widely scattered plants of B. vulgaris.

The plant Pest Control and the Field Crops Research Branches of the Agricultural Research Service, U.S. Department of Agriculture, together with the Department of Plant Pathology and Botany, University of Minnesota, participate in the activities of the Cooperative Rust Laboratory located at the St. Paul Branch Campus, University of Minnesota. The Plant Pest Control Branch is primarily responsible for the rust surveys, rust collections, race identification, testing barberries for rust reaction, reporting prevalence and severity and estimating loss. The Field Crops Research Branch and the Department of Botany and Plant Pathology are primarily responsible for the research activities.

Studies concerning the importance of barberry bushes in controlling stem rust show that:

- 1.- Stem rust infection is found on the average 10 days earlier in known barberry-infected areas than in areas free of barberry.
- 2.- Oat yields increased an average of 123% on 168 infested farms in Pennsylvania and Virginia farmers reported a 68 percent increase in wheat yields following the eradication of barberries on their properties.
- 3.- Twenty-three races were identified from uredial collections made within a 50-foot radius of a single infected barberry bush in Pennsylvania. In another Pennsylvania area 43 different races of stem rust were collected from a wheat field with barberry bushes growing in adjacent fence rows.
- 4.- Data accumulated over a 20-year period show that there were 10 times as many different races of rust found on barberry or in barberry-infested areas in the United States as were found on grains and grasses in barberry-free areas.
- 5.- Data also show that for the 16-year period 1939-1954 a different race of stem rust was identified from every 2.7 aecial collections, whereas it required an average of 42 uredial collections for each race identified.
- 6.- Records shown that races 56 and 15B of wheat stem rust and race 7 of the oat stem rust were first identified from aecial collections or from rusted grain adjacent

to infected barberry bushes, and for many years these races were found only in barberry-infested areas.

Sec. 6 - 3

Wheat Rust Epidemics in Canada in 1953, 1954 and 1955.

B. Peturson.

In the Prairie Provinces of Canada, the years 1953, 1954 and 1955 had in common certain weather conditions that influenced wheat rust development. In all three years, seeding was late while the northward movement of spores came early. Abundant moisture favored rust development each year. In 1953, as a consequence of early arrival of rust spores and heavy rains in spring and early summer, rust losses were greater than in any previous year since 1935 but the greatest damage was to durums. In 1954, late seeding, heavy rains and a great northward movement of spores into Saskatchewan, where most wheat is grown, resulted in the most severe rust epidemic in Canada's history. In 1955, late seeding and a northward movement of spores favored early establishment of leaf rust and stem rust but chiefly in Manitoba. Subsequent rust development was mitigated by two factors: first, the onset of hot, dry weather about mid-July, which hastened crop maturity; and second, the presence of a large acreage in Manitoba of the rust resistant variety Selkirk, which limited the increase of local inoculum.

It is estimated that leaf rust and stem rust reduced wheat yields in Western Canada by 43 million bushels in 1953, 130 million bushels in 1954, and 9 million bushels in 1955.

Sec. 6 - 4

Relative Ability of Four Races of *Puccinia Graminis Tritici* to overwinter in Texas.

M. C. Futrell and A. J. Pilgrim

Four varieties of wheat were seeded in 12' x 12' plots at 6 locations ranging from the northern to southern part of Texas in 1954. These varieties were inoculated with races 15B, 17, 38, and 56 of stem rust. The overwintering capacity and relative pathogenicity of each race was studied on the four varieties. No race lived through the winter north of Waco. At the four stations south of Waco no race was killed out completely on all varieties. Race 15B on the variety Nugget was the most aggressive race. Bacterial parasites of stem rust reduced the incidence of the disease during the winter. Bacteria were more prevalent at stations of high rainfall and high humidity, and appeared to

be more aggressive on some races of stem rust than others. The fungus did not overwinter as efficiently on wheats of decumbent growth as on wheats of upright growth habit.

Sec. 6 - 5

Reaction of Wheat Varieties to Three Rusts When Grown
Under Different Environmental Conditions in Guatemala.

O. N. Sosa, A. Fumagalli and F. J. Le Beau

Servicio Cooperativo Interamericano de Agricultura, Guatemala.

The principal wheat producing areas are found in the western part of the Republic at elevations of 6500 feet and above. Throughout this area the conditions are favorable for the development of the wheat plant from the time of planting until it begins to flower. The climatic conditions from flowering until the grain matures are unfavorable for the production of high quality grain, although not necessarily unfavorable from a yield standpoint. Excessive rainfall, low temperatures and soils which are very deficient in nitrogen, result in soft textured grain of low protein content.

In connection with the wheat improvement program of the Servicio Cooperativo Interamericano de Agricultura, experimental stations are maintained at the following locations and elevations: Quezaltenango 7,800 feet, Tecpán 7,000 feet, La Cienaguilla 6,500 feet, and Guatemala 5,000 feet. Additional observational plots are grown at six other locations at elevations of 10,500, 5000, 3000, 2500, 950 and 800 feet above sea level. These locations differ greatly not only in elevation, but also in temperature, precipitation, relative humidity and soil type.

When a group of wheat varieties are grown under these different climatic and soil conditions, they respond very differently from one location to another. Great differences are observed in reaction to diseases, habit of growth, and yield. For example the variety Supremo 211 develops as a semi-winter to winter wheat when grown at elevations of less than 3000 feet, whereas above this elevation it develops as a typical spring habit variety. Moreover, the reaction of most varieties to the different rusts varies greatly from one elevational zone to another.

Table 1 shows the reaction of twelve varieties of wheat to stem rust and leaf rust when they were grown under irrigation at Morán (4000 feet) in 1953. The data in Table 2 indicate the reaction of 10 of the same varieties to the three rusts when grown at three different locations during 1954. The data in Table 3 summarizes the reaction of the same thirteen varieties referred to in Tables 1 and 2, to the three rusts when grown at four locations in 1955.

Table No. 1.- Reaction of Twelve Wheat Varieties to Stem and Leaf Rust When Grown at Morán, Under Irrigation, in 1953.

Variety	<i>Puccinia graminis tritici</i> Severity/Reaction %	<i>Puccinia triticina</i> Severity/Reaction %
Frondoso	80 S	80 S
Supremo 211	80 S	0
Supremo 51	0-5 R	80 S
Amalia Klein	70 S	80 S
Regent	80 S	50 S
Nazas 48	30 S	0
Newthatch	90 S	50 S
Gabo	5 R	0
Kenya 324	50 MS	0
Kentana 48	5 R	50 S
Mayo 48	100 S	80 S
Yalta	0-5R	50 S

Table 2.- Reaction of Eleven Varieties of Wheat to Stem, Leaf and Stripe Rust When Grown at 3 Different Locations in 1954.

Variety	Quezaltenango 7800'			Tecpán 7000'			Guatemala 5000'		
	P.gr.tri Sev./Rea	P.tr. S/R	P.gl. S/R	P.gr.tri. S/R	P.tr. S/R	P.gl. S/R	P.gr.tri S/R	P.tr. S/R	P.tr.gl. S/R
Frondoso	40 S	0	0	0	50 S	20 MS	70 S	100 S	0
Supremo 211	0	0	0	0	0	100 MR	100 S	10 R	0
Frontiera	0	10 R	0	0	20 MR	60 S	100 S	40 MR	0
Amalia Klein	0	0	0	15 MS	0	100 S	100 S	0	0
Regent	0	0	0	0	0	20 MR	20 MR	10 R	0
Newthatch	0	10 R	0	0	0	100 MS	T	0	0
Gabo	0	20 S	0	0	0	0	T	80 S	0
Kenya 324	0	100 S	0	0	0	100 MR	T	T	0
Kentana 48	0	0	0	0	50 S	0	0	70 S	0
Yalta	0	100 S	0	0	0	100 MR	T	60 S	0
	0	T	0	0	0	0	60 S	0	0

Table No. 3.- Reaction of Thirteen Varieties of Wheat to Three Rusts When Grown at Four Locations, in 1955.

Variety	Quezaltenango 7000'			Tecpán 7000'			Cieneguilla 6500'			Guatemala 5000'		
	Puccinia			Puccinia			Puccinia			Puccinia		
	gr.tri.	tri.	gl.	gr.tri.	tri.	gl.	gr.tri.	tri.	gl.	gr.tri.	tri.	gl.
Arondosa	20S	0	25 MR	0	5 S	15S	40 S	30 S	0	0	20 S	0
Supremo 211	0	0	20 S	0	0	20S	90 S	TR	0	0	0-55	0
Frontiera	0	0	60 S	0	20 S	0	80 S	20 S	0	0	0	0
Supremo 51	0	0	25 R	0	0	10S	5 S	10 S	0	0	0	0
Malva Klein	0	0	60 S	0	10 S	30S	30 S	40 S	0	0	0	0
Regent	0	0	20 S	5S	0	0	10 R	60 S	0	0	80 S	0
Alazas 48	0	20S	0	0	0	0	90 S	50 S	0	0	20 S	0
Newthatch	0	0	60 S	10S	0	30S	40 S	50 S	0	0	0	0
Abasco	0	0	40 S	0	0	0	60MS	5MR	0	0	T	0
Kenya 324	0	0	60 S	0	T	50S	40 S	60 S	0	0	0	0
Centana 48	0	0	30 R	0	10 S	0	2 R	60 S	0	0	5-S	0
Mayo 48	0	5S	0	0	0	15S	10 S	30 S	0	0	0	0
Alta	0	0	0	0	0	0	10 R	80 S	0	0	0	0

These results indicate :

- 1) That wheat varieties planted at lower elevations are generally more severely attacked by Puccinia graminis tritici, probably because of more optimum conditions for the parasite, or perhaps as a result of a loss of resistance by the host.
- 2) The severe attack of stem rust at lower elevations corroborates the hypothesis that the culture of wheat at lower elevations was abandoned many years ago because of disastrous epidemics of stem rust.
- 3) The problem of stripe rust is limited to the principal areas or elevations where wheat is grown commercially, being of no importance at lower elevations. Severe infections have, however, been observed when wheat is grown with overhead irrigation during the winter months, at elevations as low as 5000 feet.

Sec. 6 - 6

General Considerations Pertaining to Rusts of Wheat in Guatemala.

A. Fumigalli, O. N. Sosa and F. J. Le Beau.

Servicio Cooperativo Interamericano de Agricultura, Guatemala.

In the zones where wheat is currently grown commercially, stem rust is not a serious problem. Undoubtedly the climatological condi-

tions, especially low temperatures (average maximum of 25.75°C and average minimum of 1.08°C), are not favorable to the rapid development of the pathogen. There, however, appear to be several other factors which limit the development of stem rust, namely:

1.- The system of planting in small plots on raised beds, on poor soils where little or no fertilizer is used combined with light rates of seedling is practiced resulting in sparse stands of poorly developed plants. The microclimate in such a stand is unfavorable to the development of epidemics.

2. The great genetic variability in the "criollo" ("native") varieties probably tends to retard the development of epidemics. These varieties are usually mixtures of several phenotypes and most certainly possess even greater genotypic variation. In these mixtures there exists a great deal of variation with respect to reaction to stem rust. These mixtures are certainly not conducive to the rapid development of stem rust epidemics.

Although in recent years stem rust has been serious in relatively few localities at the higher elevations, these cases have clearly indicated the potential danger from this disease. For example in 1951, 1952 and 1953 the area of Amalia Klein, which is very susceptible to stem rust, increased considerably. During 1953 this variety was damaged severely by stem rust, especially on land that was fertilized heavily. In contrast to the relatively low hazard from stem rust at the higher elevations, experimental planting made at lower elevations have shown that this disease is a limiting factor under the higher temperatures of the latter zone. The severe hazard and losses from stem rust at the lower elevations undoubtedly explains the reason for the abandonment of wheat production in the vicinity of Amatitlán at an elevation of 3900 feet within the past century. Similarly the cultivation of this crop was abandoned in the region of Jalapa at 3400 feet and more recently in the valley of Chimaltenango at 5700 feet.

The life cycle of Puccinia graminis tritici under Guatemalan conditions has been studied only very superficially. It is believed the pathogen maintains itself in the uredinial stage throughout the year, since small plots of wheat are found growing in some areas of the country every month of the year. Moreover, stem rust has been observed on a number of grasses and these hosts may also aid in maintaining uredinial inoculum throughout the year.

Although there is no experimental or observational evidence to support the theory it is possible that Puccinia graminis tritici completes its sexual stage on species of Berberis or Mohonia under certain conditions. "Palo Amarillo" Berberis pinnata lag (1803) (Syn Odosteman fascicularis (DC) Abrams 1910) is distributed in the principal wheat producing zones of the Republic. Stanley and Steyermark in "Flora de Guatemala" also have reported the occurrence of several species of Mohania.

It is also possible that under certain conditions prevailing Northeast winds bring spores into Guatemala from wheat producing areas in neighboring countries to the north. A study of the meteorological charts of the Continent indicates that large air masses move in a parabolic course across the prairie Provinces of Canada, Great Plain of the U.S.A., central Mexico and sometimes swing into Central America. Such air currents are probably responsible for the recent introduction of 15B into Guatemala. Recent studies employing spore traps at the experimental station "Labor de Ovalle" at Quezaltenango, has shown that sometimes airborne stem rust spores begin to appear in April, which is two months before the initiation of the planting season in the important wheat producing areas of the country.

Climatic conditions during the past two years have been unusually favorable for the development of Puccinia glumarum. Perhaps another reason for the increase in severity of this rust is related to change in varieties which are being cultivated. Among the "criollo" varieties, which were formerly extensively grown, the great phenotypic variation with many of the types also possessing a high degree of resistance to P. glumarum, gave considerable protection. Since 1951 there has been a great shift in the varieties which are being grown. Supremo 211 has replaced the criollo varieties to a large extent in the most important wheat producing regions. This variety has proven to be very susceptible to Puccinia glumarum, and this change has probably contributed to an increase in the severity of stripe rust.

Sec. 6 - 7

Losses Caused by Rusts of Wheat in Argentina from 1944-1955.

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The first report of losses from rust on wheat in Argentine was recorded by Báez in 1578. From this date until 1821 there are no additional published records of rust damage. Published records from 1821 and 1922 indicate serious rust epidemics developed during these years in the provinces of Entre Ríos and Santa Fe in the region adjacent to the Paraná River. These latter records coincide with reports from Brazil which indicate that severe rust epidemics, apparently caused by P. graminis, developed in the wheat producing area of Brazil during this same period. The epidemics in Brazil were of

(1) The authors wish to acknowledge the assistance of Ings. J. Martinez, E. Favret, J. Sarasola, N. Horowitz and C. Cialzeta.

such magnitude that they essentially stopped the expansion and development of wheat farming in that country. During the latter part of the 19th century and the early years of the 20th century, Segazzini, Gasner, Huergo, Hauman and several others reported economic losses from P. tritici and P. triticina in Argentina.

Despite the increasing importance of wheat production in the Argentine economy, up until the present time there has been very little precise information on the losses caused by rusts. The information available has been only of a very general nature and does little more than indicate those years when losses have been greater than usual.

The appearance of P. glumarum in 1929, followed by the severe epidemic of stripe rust in 1930 caused great alarm among both farmers and agronomists. Marchionetta following these epidemics made an attempt to determine experimentally the damage caused by P. glumarum and other pathogens of wheat. His estimates of losses were of a general nature and were based upon observations in commercial plantings. Very serious losses from stripe rust (P. glumarum) are known to have occurred in 1930 and 1931. The losses from this disease since 1931 have decreased and although it is endemic in most years, with the exception of 1935, it has not reached epidemic proportions in any of the wheat producing areas of the Republic. The area where the greatest hazard from stripe rust exists is in the southern region of the Province of Buenos Aires.

The estimates of damage by stem rust is based largely on notes of scientists employed in the División de Fitopatología del Ministerio de Agricultura. These records indicate that severe losses from stem rust (P. graminis) occurred in 1914, 1925, 1929, 1938, 1939, 1940 and 1943. The losses in 1925, 1939 and 1943 were especially severe.

Marchionetta estimated the losses from P. graminis in 1929 reached 150 million pesos, and the losses from stripe rust in 1930 were estimated at 200 million. Other estimates of losses include those of Fudorf who has estimated that the three rusts are annually responsible for a reduction of 10 percent in overall production. On the basis of the limited information available, Vallega and Favret estimated the annual loss, over the 25 year period from 1923 to 1949, was 15 percent.

Because of the need for more accurate information a study was undertaken in 1949 by the authors to determine more precisely the losses caused by rusts of wheat.

The method which has been used as a basis for developing estimates of losses consists of making two or three inspection trips in each of the wheat producing regions annually. In the course of these trips approximately 500 fields are examined at random, with more observations being made in the most important production areas. Rust severity and distribution are recorded for each field examined; and on the second or third inspection trip the fields are classified both with respect to variety of wheat and the severity of rust. On

the basis of this information each year a map is prepared for each subregion showing the intensity of rust attack.

Supplementary information is obtained each year from observations made on experimental plantings at Castelar, which contain all of the commonly grown commercial varieties. In these experimental plots yields of each variety is determined and these yields are correlated with rust severity (taking into consideration independently both P. graminis and P. triticina).

The calculation of losses from rust is done independently for stem and leaf rust each year on a subregional basis. In making these calculations the average attack observed in the commercial fields examined in each subregion expressed in percentage (severity of infection) is multiplied by the area of each variety cultivated in the region or subregion, and this figure in turn is multiplied by the coefficient of damage produced by the rust on each variety. Then using as a base the actual production figures in tons for each region, the losses or reductions in yields can be calculated independently by regions.

Recognizing the errors which are inherent in this system, we still feel that the method currently being used is serving a useful purpose and provides information which is more accurate than that which was previously available.

Results obtained during the past 7 years indicate that P. graminis only produced damage of great importance in 1950, when the national production was reduced by 950,000 metric tons, which represented a loss of 16.3 percent. In the remainder of the period the maximum loss recorded was in 1952 when yields were reduced 4 1/2 percent by stem rust. The average losses over the period from 1949 to 1955 are estimated at 4.3 percent.

The most important losses from stem rust are usually confined to the northern half of the wheat producing area which corresponds to subregions I, II, III and V N. However, in certain years losses also occur in subregion IV, which includes the southern part of the Province of Buenos Aires. The subregion where most serious losses have occurred is II N, which is also the area which has the greatest concentration of wheat culture. During 1950, of a national loss of 950,000 tons, nearly half was confined to this subregion.

The most serious losses from leaf rust (P. triticina) during this period, occurred in 1949 and 1951, when losses of 7 percent were recorded. The losses for the other 5 years of this period varied from 2.2. to 5.5 percent, with an average loss of 4.26 percent for the entire period. Leaf rust epidemics occur most frequently in subregions I, III, and V N, but in some years occur in all subregions.

A comparison of losses caused by P. graminis and P. triticina during this entire period shows them to be of a similar magnitude. However, losses from P. graminis are more serious from an economic

viewpoint since in certain years large-scale epidemics develop which may result in great reductions in yield over a very large area.

Sec. 6 - 8

The Rust Problems of the Important Wheat Producing Areas
of Mexico.

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The commercial cultivation of wheat in Mexico can be traced back to 1529, according to some authorities. Apparently the initial commercial plantings were made in the area which is now the City of Mexico.

Up until the last three years the national production of wheat has been greatly inadequate for domestic needs. Wheat, in most areas where it is adapted, until recently could not compete economically with cotton and corn. Within the past three years, however, the increase in wheat yields, especially in Sonora, Sinaloa and the Bajío region have greatly stimulated wheat culture and resulted in great increases in production.

The principal wheat producing regions of the Republic are the following: 1) The Northwest Region, includes the States of Sonora, Sinaloa, Baja California del Norte and the Territory of Baja California Sur. The wheat producing areas of this region lie in an elevational zone ranging from slightly above sea level up to an elevation of 150 meters. 2) The Bajío Region includes the States of Querétaro, Guanajuato, Jalisco and Michoacán. The principal producing areas of this region lie between 1200 to 1700 meters above sea level. 3) The Laguna Region, includes an area in Durango and Coahuila lying between 1000 and 1200 meters. 4) The North Central Region includes the wheat producing areas of the States of Aguascalientes, Zacatecas, Durango and San Luis Potosí lying between 1900 and 2500 meters. 5) The Region of the High Valleys of the Mesa Central includes the areas between 1900 and 2400 meters in the States of México, Hidalgo, Puebla, Tlaxcala and Oaxaca.

Wheat is grown principally as an irrigated winter crop in all of these regions. The crop is planted during November, December and the early part of January and harvested during April, May and June depending upon the elevation. All varieties are of spring habit.

During the 1955-56 season the area planted to wheat is ap-

proximately 850,000 hectares, of which 350,000 hectares are located in the Northwest Region. It is estimated that the national yield will average 1.5 tons per hectare (22 bushels per acre) thereby resulting in a total production of between 1,100,000 and 1,200,000 metric tons. Domestic annual requirements are currently estimated to be 1,000,000 metric tons.

The principal disease problem of wheat in all regions is stem rust. Since 1948 this disease has been held in check by the use of rust resistant varieties, and losses have been greatly reduced. Although leaf rust is present in all regions it is the least important of the three rusts found on wheat in Mexico. Stripe rust (P. glumarum) becomes a serious problem at the higher elevations, and is second in importance only to stem rust as a limiting factor in national production.

Within the past three years extensive commercial plantings of wheat have been made in the high valleys of the Mesa Central during the summer rainy season. The introduction of this type of wheat culture was impossible before the development of stem and stripe rust resistant varieties. Wheat in many of these higher valleys is now more remunerative than corn. Yields of up to 3.8 tons per hectare have been recorded with an average yield of about 1.5 tons per hectare.

Several changes in the races of stem rust population have been encountered in the past 10 years, which has necessitated changing the commercial wheat varieties to prevent serious losses. In 1948 the prevalent stem rust races were 17, 19, 38, 56 and 59. The varieties Mayo 48, Chapingo 48, Yaqui 48, Kentana 48, Lerma 50 and Supremo 211, were distributed between 1948 and 1950, were all resistant to this group of races. The first three varieties were derived from a cross of Marroqui 588 x Newthatch. Kentana 48 was derived from a cross of Kenya C9906 x Mentana, while Lerma 50 was a variety derived from backcrossing Kentana 48 to Mentana. Supremo 211 was selected from a cross of Surpresa x Hope-Mediterranean, made by Dr. Mc Fadden in Texas.

The appearance and rapid multiplication of Race 15B in 1951 necessitated changes in varieties. Of the six varieties referred to above, all but Kentana 48 and Lerma 50 proved to be susceptible to this race. As a result these two varieties increased rapidly in popularity, especially in the Bajío and Central Regions, during 1951 to 1953. These varieties probably were grown on more than 90 percent of the area cultivated to wheat in Central Mexico in 1953. During 1953 a second group of closely related races, namely, 29, 48, 49, 125 and 139, all capable of attacking Kentana 48 and Lerma 50, made its appearance. These races increased rapidly in prevalence during 1954 and 1955, and necessitated changing varieties to avoid losses.

As a result of these two changes in races it has been necessary to develop varieties with resistance to races 15B, 17, 19, 29, 38, 48, 49, 56, 59, 125 and 139. To meet these needs the varieties Chapingo 52, Chapingo 53, Bajío 53 and Mexe 53, all derived from a

cross of Yaqui 48 x Kentana 48 were multiplied. Moreover, the early maturing varieties Mayo 54 and Sinaloa 54, derived from crossing (Egypt 101 - Timstein) x Mayo 48, and Gabo 54 and Cajeme 54 derived from crossing Gabo x Kenya C9906 have been released. More recently Yaqui 54 derived from crossing Yaqui 48 x (Timstein-Kenya)₂ Lerma Rojo derived from crossing Lerma 50x(Yaqui 48 x María Escobar² - Supremo), and Yaktana 54 derived from crossing (Yaqui 48 sib - Kentana 48 sib) x Frontana have been released to farmers.

The Yaqui and Gabo derivatives are varieties which can only be grown successfully on the coast because of their susceptibility to stripe rust at higher elevations. The Lerma, Kentana, and Yaktana varieties can be grown at all elevations.

Although the prevalent races of stem rust at the present time includes only 15B, 29, 48, 49, 125 and 139 the varieties which have been released recently possess moderate to good resistance to all 11 races listed above. This is necessary since some of the old races continue to persist in nature on wild grasses and barley, even though they are now very rarely isolated from wheat.

Sec. 7 - 1

Summary of Research on the Physiology of Wheat Stem Rust being conducted in the Department of Botany, University of Manitoba.

E. R. Waygood and P. K. Isaac.

The response of germ tubes to contact with various artificial and natural surfaces has been studied with the view of understanding some of the stimuli that lead to the formation of haustoria. It has been shown that there is an intimate contact established with leaf surfaces and the composition and molecular orientation of these can determine the direction of growth.

Electrokinetic methods are being used to follow the changes that take place in surface composition of the growing germ tubes. Simultaneously information is obtained of the effect on the permeability of the fungal wall of such substances as those present in host cells. It is hoped that these studies will give an indication of the nature of the interaction between the host cell and the rust hyphae and of the mode of nutrition of the parasite.

In addition to the biophysical approach, complementary biochemical and histological studies are in progress. The first, concerned primarily with protein synthesis by the fungus and the mechanism of the hydrolysis of fungal cell wall constituents, and the second with the effect upon haustorial formation of the physiological condition (eg.

nutritional status) of the host tissue. A third study is being made on the role of manganese in the processes controlling growth in wheat leaves by auxin.

Sec. 7 - 2

Research on the Physiology of the Host-Parasite Relations
of Rust and Mildew Fungi.

M. Shaw and D. J. Samborski.

The work outlined here has been carried out with the assistance of the following research students: T. G. Atkinson, M. W. Ali, N. Colotelo, A. Hawkins and R. Krupka. Almost all of the work is as yet unpublished, but two preliminary papers have appeared in print and detailed paper (on section III, below) has been submitted for publication. It is not proposed to give here a detailed account of the work, but rather to outline the scope of the program which is in progress.

The research falls naturally into five sections as follows:

I.- Studies on spore germination, particularly mildew conidia, on artificial media and cytochemical studies on penetration and haustorial formation in the host. On artificial media it has been possible to induce branching and the formation of septa in mildew "germ tubes". It has been shown that haustoria are high in phosphatases and the possibility is envisaged that these enzymes may play a role in the transport of substrates across the haustorial membrane.

II.- Studies on N metabolism of healthy and rust infected resistant (Khapli) and susceptible (Little Club) wheats. On Little Club there is a marked increase in dry weight but only a slight fall in % total N at infections. On Khapli there is no increase in dry weight and a marked fall in total N. Free amino acids have been measured by quantitative paper chromatography. It is thought that there is a more rapid breakdown of protein at resistant than at susceptible infections. Treatments which prevent the rapid loss of N, such as excision or the application of maleic hydrazide, cause a breakdown in the resistance of Khapli.

III.- The accumulation of radioactive substances at infections. Accumulation of C^{14} , P^{32} and Ca^{45} is marked at infections on Little Club. Accumulation parallels the respiratory rise at infections and can be inhibited by anaerobiosis and respiratory inhibitors. Accumulation at infections on Khapli is less marked.

IV.- Respiratory studies. The respiration rates on excised infections have been expressed on the basis of unit area, total dry weight and total N. The data show that the rate of increase in respir-

ation at infections on Khapli is greater than at infections on Little Club. However, on Little Club the respiratory rise is of greater duration and the peak value is greater than in Khapli.

The effects on oxygen consumption of respiratory inhibitors, including dinitrophenol, and the rates of fermentation of excised infections have led to studies on the metabolism of radioactive sugars. The results indicate a shift in the respiratory pathway in infected tissue such that a smaller proportion of the carbon respired passes through the E.M.P. (Embden-Meyerhof-Parnas) pathway.

V.- Studies on indole-acetic acid metabolism. Using Radioactive indole-acetic acid, data have been obtained which indicate that infections on Little Club destroy indole-acetic more slowly than healthy tissue, whereas infections on Khapli destroy indole-acetic acid more rapidly than healthy tissue.

The possibility exists that these auxin relationships are connected with the patterns of protein and respiratory metabolism in the two types of infected tissue. Further work may elucidate some of these relationships.

Sec. 7 - 3

Studies on the Nature of Rust Resistance in Cereals.

F. R. Forsyth.

Research into the nature of rust resistance in cereals is proceeding along the three main divisions noted below :

1.- The nature of the inhibiting substance emitted by germinating urediospores of Puccinia graminis var. tritici has been under investigation and was the subject of a paper published in Can. J. Botany 33: 363-373. 1955.

The self inhibition of germination of urediospores of Puccinia graminis Pers. var. tritici Erikss. & Henn. has been consistently demonstrated in Warburg flasks. Four ways of overcoming the effect of the inhibitory substance have been found: use of a sufficiently large volume of water in relation to weight of spores; the placing of a silver nitrate solution in the centre well; and the introduction of acetone or ammonia vapor into the flask atmosphere. The vapor of trimethylethylene inhibits germination of the urediospores in the same way that the natural inhibitor does, and the same means can be used to counteract its effects. The similarity of the absorption spectra of the inhibitor and of trimethylethylene in acetone solutions indicates that trimethylethylene is the natural inhibitor.

For the present, we are assuming that the rust hyphae would

produce trimethylethylene while growing in a medium of host cells. This substance, by increasing the permeability of the host cell, could cause a tendency toward susceptibility in the host. The nullification of its effects by ammonia would tend to increase resistance.

2.- Attempts are being made to determine the chemical basis for the increased susceptibility of Khapli wheat after DDT (Dichlorodiphenyltri-chloroethane) treatment. A short paper was published in Nature (London) 173: 827. 1954.

By using the technique of paper chromatographic analysis we determined that as a consequence of the leaf being sprayed with DDT solution the concentration of free amino-acids increased. Whenever an amino-acid was present in both the exact from the control and the treated leaves it was present in greater amount in the latter.

The sugars sucrose, fructose and dextrose are also present in greater quantities in the DDT treated than in the non treated leaves.

Evidently the DDT alters the metabolism in such a way that free amino-acids and simple sugars accumulate in the leaf. The effect may be due to an inhibitor of synthesis of proteins and carbonhydrates. However, the dry weight of the treated seedling leaf increases more rapidly than does that of the non-treated leaf. This would suggest that certain substances that normally are transported during the ontogeny of the leaf are not translocated from the treated seedling leaf.

3.- The effects of quality and intensity of light, of photoperiod and of temperature variations on the uredial stage of P. graminis var. tritici on wheat are being investigated.

Four growth chambers are being used in these studies. It is now possible to control the light quality, intensity and duration, the temperature to within $\pm 1^{\circ}\text{F}$, and the humidity to within 5 to 8% relative humidity.

An interaction of temperature and light on the seedling reaction of McMurachy wheat to race 15B of stem rust has been studied. The reactions of seedlings were determined, in growth chambers, under various combinations of temperature and light. Experiments in continuous light on seedlings kept at temperatures alternating between 62°F and 72°F showed that the critical period determining reaction to rust was the time at which signs of infection (i.e., flecking) became visible. Experiments involving temperatures of 60° , 70° and 75°F at a photoperiod of 16 hours, with 8 hours of darkness, showed that a single 16-hour period of low temperature (60°F) and light induced resistance to the rust if this period fell between 51 and 115 hours after inoculation but was most effective if it occurred between 75 and 91 hours.

Sec. 7 - 4

Rust Extracts Toxic to Wheat

Helen Hart and Mary Ann Swaebly

Institute of Agriculture, St. Paul, Minnesota.

Germinating urediospores of the wheat stem rust fungus, Puccinia graminis Pers. var. tritici (Erikss. and E. Henn.) Guyot, produce a toxin that damages cells of wheat seedlings in the same manner as does an infection by the living rust fungus. Extracts from urediospores that had germinated on buffer solutions were introduced, by partial vacuum technique, into the wheat leaf where they caused chlorotic flecks, cell wall damage in the substomatal areas, and leaf tip necrosis. Control buffer solutions were not injurious to the wheat tissues. The toxin is heat-labile and loses its activity after 10 minutes at 100°F., but within the wheat seedling it has greater activity at 90°F. than at 65°F. Extracts from races 15B, 11, and 56 were more toxic to selections of Kentana wheat than to Little Club wheat.

Sec. 7 - 5

Sugars and Sugar Alcohols that Influence
Development of Wheat Stem Rust

Wm. Silverman and Helen Hart

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Sugars and sugar alcohols affect the growth and sporulation of race 15B of stem rust in detached leaves of Little Club wheat more than do amino acids, vitamins, and numerous antimetabolites. Primary leaves, inoculated with rust urediospores, were detached from wheat seedlings, when rust flecks appeared and 0.3 M solutions of sugars or sugar alcohols were applied to the basal portions of the leaves. The hexoses, glucose and fructose, and the disaccharides and trisaccharides composed of glucose and/or fructose moieties, induced vigorous growth and abundant sporulation of the rust fungus. Pentoses, and the hexoses other than glucose and fructose, did not favor rust development. Sugar alcohols retarded rust development and induced blackening in urediospores, in rust mycelium near the spore-forming portion of the uredium, and in walls of wheat cells adjacent to that area. Only from 1 to 3 percent of the urediospores germinated. Sorbitol and mannitol were most effective as blackening agents, arabitol and dulcitol less effective. Blackening ceased and normal rust development resumed if the sugar alcohol was withdrawn and a sugar solution was substituted.

Amino Acid Content of Uredospores of Five Races of Wheat
Stem Rust.

M. C. Futrell.

A preliminary study has been made of the amounts of seven amino acids (isoleucine, leucine, lysine, methionine, phenylalanine, threonine and valine) present in ungerminated uredospores of races 15B, 17, 29, 38, and 56 of Puccinia graminis tritici Erick. and E. Henn. The spores of race 15B contained the least amounts of six of the seven amino acids studied. The greatest variability between races occurred in methionine content and the least variability occurred in the phenylalanine content. It is suggested that a thorough study of the amino acid content of rust urediospores might through light on the genetics of pathogenicity and host specialization.

Rust Development in Flax Tissue Cultures.

G. A. Ledingham and Franziska Turel.

In normal rust infection of flax leaves with Melampsora lini a heavy crop of uredospores is produced in 8 to 10 days. Under ordinary greenhouse or field conditions there is no tendency for the rust mycelium to develop on the epidermal surface. However, under conditions suitable for the development of tissue cultures from leaf fragments the mycelial growth of rust can be stimulated so that hyphae of 1 to 2 mm. in length form a thick white mat over the leaf epidermis. Infected cotyledons are best suited for tissue culture development and through careful sterilization techniques approximately 50% of the cultures may be obtained free from bacterial or fungus contaminants. Studies have been made on the four basic tissue culture medias developed by White, Gautheret, Knop and Heller.

Starting with Knop's basic medium experiments were carried out to determine the effects of adding indole-3-acetic acid, coconut milk, various nitrogen sources and amino acids as well as vitamins and growth factors. Some compounds stimulate mycelial growth without affecting callus growth, whereas others stimulate the latter and may inhibit rust development. Ammonium nitrate exerts a beneficial effect on callus growth and stimulates early development of rust mycelium. However, mycelial growth is usually scanty and tends to be covered over by new callus tissue. Without NH_4NO_3 the hyphae grow in large thick patches almost entirely covering the callus surface. Uredospores and teliospores in all stages of development are frequently borne on the mycelial hyphae.

A vacuum drying process for preservation of Puccinia graminis.

Donald M. Stewart

Fresh uredospores of Puccinia graminis varieties tritici, avenae, and secalis that had been mixed with dry hemin, dried for 30 minutes under vacuum, sealed, and kept at room temperature for 300 days infected from 25 to 94 percent of the plants inoculated, depending on rust race and host species, compared with 0 to 6 percent infected by spores similarly stored but without hemin. Bovine albumin powder, plain unflavored gelatine, and granular casein were inferior to hemin. Spores of avenae refrigerated at 12°C. for 234 days in cork-sealed vials and then mixed with hemin infected an average of 72 percent of the test plants as compared with 19 percent without hemin.

Tests with Chemicals for Rust Control.

B. Peturson and F. R. Forsyth.

Experiments have been carried out at the Plant Pathology Laboratory, Winnipeg, Manitoba, to determine the value of a number of fungicides for rust control purposes. During the period 1951 to 1955 the following fungicides were tested under field conditions: Acti-dione, calcium sulfamate, Nabam + zinc sulfate, Fermate, Karathane, Manzate, Phygon XL, sodium sulfanilate, sulfur, Thioneb and Zineb.

The fungicides afforded various degrees of protection from rust if applied several times during the season. Of the ones tested Nabam + zinc sulfate, colloidal sulfur, Manzate, Thioneb and Zineb were the most effective.

In 1952, plots dusted five times during the season at the rate of 40 pounds per acre with colloidal sulfur, Manzate, and Zineb yielded 32.1, 28.6, and 36.9 bushels per acre, respectively, while the check yielded 15.4 bushels per acre. In other years differences in yield between plots treated with these fungicides and the checks were much smaller. In 1955, Thioneb treatments increased yields by about 10 bushels per acre. Fermate, Karathane, Phygon XL, and sodium sulfanilate gave some rust control but were inferior to Manzate, sulfur, Thioneb and Zineb.

Acti-dione, in a field test, reduced rust temporarily, but damaged the younger leaves and produced no increase in yield.

Calcium sulfamate proved to be a good rust eradicator under

greenhouse conditions and checked rust development in the field. However, it damaged the plants and caused substantial yield reductions. The seed from calcium-sulfamate treated plants germinated poorly.

CMU (p-chlorophenyl dimethylurea) applied to the soil had no effect on rust development or yield.

Sec. 8 - 2

Some Observations on the Chemical Control of Stem Rust
in Durum Under Field Conditions in 1955.

W. P. MacDonald

F. H. Peavey & Company, Minneapolis, 15, Minnesota.

The chemical designated by the coined name Nabam sold commercially under the trade name Dithane-14 and manufactured by the Rohm & Haas Company, was applied in a series of field scale tests in northern North Dakota in 1955. From 5 acres to 100 or more acres were treated on 17 farms. With one or two exceptions, three applications were made with an effort to time the treatments at the shooting, early heading and fully headed stages. The material was applied at the rate of 2 quarts of product plus 3/4 pound of zinc sulphate, plus 1/2 ounce of a commercial spreader-sticker, in approximately 30 gallons of water per acre for each of the three treatments. There was substantial visual evidence of fewer rust pustules on the treated area even though rust damage to untreated fields was not severe. For the 17 farms treated, the average increase in yield from treatment amounted to 4.9 bushels per acre and the test weight was increased by 2.9 pounds per bushel. Cost per acre for three treatments, including application, would be approximately \$6 whereas the value of the durum at harvest time would be approximately \$3 per bushel, indicating a substantial profit for the operation. Although the spray is rather awkward to handle because of the large volume of solution required and compared to some other agricultural sprays, is relatively expensive, there is considerable evidence that farmers will use such a spray in the future when rust threatens.

Sec. 9 - 1

Origin of the Variety Timstein.

I. A. Watson

In recent years a great deal of confusion has evolved throughout the Americas concerning the variety known throughout these conti-

nents as Timstein. This variety has been used as a parent in many breeding programs.

It is now known that the variety of common wheat named Timstein, C.I. 12347 did not arise from the cross (Steinwedel x Triticum timopheevi) as was formerly believed, but rather from the cross Bobin² x Gaza). Consequently its rust reaction is similar to that of Gabo which came from the same cross.

Material of the cross (Steinwedel x T. timopheevi) is available from sources in Australia but no variety having this pedigree has been named. It is possible that a variety will be named shortly from this cross but it will not be called Timstein.

Sec. 9 - 2

Response of Wheat to Fertilization in the Mexican States of Guanajuato and Michoacan.

R. J. Laird, Samuel A. Yépez and Sabino Chávez

One of the most important wheat areas in Mexico lies west of Mexico City in the region known popularly as the Bajío. This agricultural area, which occupies most of Guanajuato and parts of Michoacan and Queretaro, has been used in the production of grain crops for several centuries. In general the soils are dark, heavy clays of alluvial or lacustrine origin. The amount of organic matter in the soils usually varies between one and two percent; soil pH values usually fall between 6.5 and 8.0. The altitude of this region varies between 1500 and 2000 meters above sea level. The climate is of the plains type with dry winters and wet summers. Average annual temperature varies from about 15° to 19°C; average annual rainfall varies from about 22 - 30 inches per year.

Wheat is generally planted in the Bajío during the last of November and December and harvested in April and May. As this is the dry season of the year the moisture requirements of the wheat are supplied by irrigation.

During the wheat seasons in 1953-54 and 1954-44, the response of wheat to applications of nitrogen, phosphorus and potassium was studied at 13 locations. Wheat yields were increased by nitrogen applications at all locations. Phosphorus applications significantly increased yields at 5 locations. Yields were not significantly affected by application of potassium at any location.

Applications of nitrogen up to 120 kilos per hectare generally gave profitable increase in yield. As an average of the 13 locations, yields were increased from 1.4 to 2.8 tons per hectare by the application of 120 kilos of nitrogen per hectare.

The response of wheat to nitrogen applications generally followed a parabolic-type curve. That is, the magnitude of the increase in yield per unit of applied nitrogen was inversely proportional to the size of the yield without the added nitrogen. For the experiment conditions studied it was found that the application of 40 kilos of nitrogen per hectare to a soil which produces 1000 kilos of wheat per hectare without added nitrogen will increase the yield 750 kilos per hectare, while the same application of nitrogen to a soil which produces 2000 kilos of wheat per hectare without added nitrogen will increase the yield by only 470 kilos per hectare.

Studies of the response of wheat to heavy applications of nitrogen indicated that the size of the increase in yield from applications of more than 120 kilos of nitrogen per hectare were smaller than predicted from an extrapolation of the parabolic response curve calculated from data obtained with small applications of nitrogen. This deviation from the parabolic curve is believed due to another productivity factor whose effectiveness in reducing yields became progressively greater as yields increased. This factor was probably soil moisture. Studies presently underway indicate that wheat yields are generally reduced from 10 - 30% by soil moisture deficiencies in commercial wheat fields of the Bajío.

Sec. 9 - 3

Effect of Nitrogen Fertilization on Protein Content of Wheat.

Samuel A. Yépez and R. J. Laird.

The effect of time of application of nitrogen and amount of nitrogen applied on the percent protein in wheat was studied at six locations in Guanajuato and Michoacan in 1954-1955.

The average percent protein in the wheat without fertilizer at the six locations was 11.2. The yields without fertilizer in these experiments varied from 0.4 to 1.9 tons per hectare. The application of 60 kilos of nitrogen per hectare reduced the percent protein in the wheat to 10.1. This application of nitrogen increased yields by 0.8 tons per hectare. The application of 120 kilos of nitrogen increased yields by 1.4 tons per hectare and produced a wheat containing 11.3% protein. The application of more than 120 kilos of nitrogen per hectare had little effect on yields but increased the protein content. Wheat receiving 180 kilos of nitrogen per hectare contained 13.7% protein.

The reduction in protein content of the wheat fertilized with 60 kilos of nitrogen per hectare was probably the result of a soil nitrogen level adequate for rapid growth during the first couple of

months of the growing period followed by a low nitrogen level during the formation of the grain. This condition would result in the production of large plants capable of manufacturing sufficient carbohydrates for the production of a large amount of grain. However, with all of the applied nitrogen absorbed during the early part of the cycle, nitrogen became the limiting factor in the formation of the grain. The amount of grain produced was the maximum possible employing the available nitrogen. Therefore, a low protein wheat was produced. Wheat grown without nitrogen or with a large amount of nitrogen contained a higher percent of proteins as the available nitrogen level was uniform throughout the growth cycle so that the supply of carbohydrates or both carbohydrates and nitrogen were limiting factors in the formation of the grain.

Applying all of the nitrogen at planting time or one-half of the nitrogen at planting time and the other half one month later had the same effect on protein content and yield of wheat. However, where one-third of the nitrogen was applied at the time of heading, the percent protein in the wheat increased and the yield declined.

Sec. 9 - 4

Milling and Baking Quality Characteristics of Colombian Commercial and Experimental Wheats.

H. Reaga S., M. Zapata B. and L. A. Valbuena.

Colombia imports approximately 60,000 tons of wheat annually. The importation represents approximately 33 1/3 percent of wheat or wheat products which is consumed. The importations which are made are restricted to varieties with strong gluten properties usually obtained from Canada and the United States. These imported strong wheats are blended with the commercially grown Colombian varieties which are largely of the soft type, in order to improve the baking quality of the latter.

As the national production of wheat increases thereby necessitating smaller and smaller importations of high quality Canadian and U. S. wheats the factor of quality in domestically grown wheat will increase in importance. The varieties developed for release to farmers in the future therefore, in addition to possessing high yield, resistance to the principle diseases, satisfactory agronomic type, must also have improved milling and baking characteristics if they are to meet the needs of the industry. Anticipating this shift in emphasis, the Ministry of Agriculture recently has established an experimental milling and baking quality laboratory. The methods and procedures used at this laboratory are similar to those used at the United States Department of Agriculture Quality Laboratory at Beltsville, Maryland.

The data which is summarized in Table No. 1 includes the criollo check varieties Bola Picota, Ciento Cincuenta (150), the improved commercial varieties Menkemen and Bonza, the experimental check varieties Mentana 48, Frocor, and (Kentana-Frontana) x Mayo 48 which are extensively used as parents in the breeding program, and as a quality reference or standard imported grain of the variety Marquis from Canada. Moreover, a sample of imported Gold Medal flour has been used as an additional check on baking characteristics. The experimental varieties, which are compared to the aforementioned check varieties in Table 1, are those which have shown outstanding promise in yield trials.

A considerable number of lines which have been tested compare favorably or are superior to the check varieties. The most promising of these lines are :

(Kentana - Frontana) x Mayo 48	II 947-4b-7b-2b-1B
(Galgals - Kenya) x Newthatch	II 1560-1b-4b-1b-1T
(Mentana x (Centela - Frontana)	II 1523-3b-9b-1b-3R
(McMurachy - Kentana) x Yaqui 50	II 1571-3b-3b-1r-1B
(Klein Cometa (Newthatch-Mentana) x Menkemen	II 1879-7b-4b-2b-1B
" " " "	II 1879-7b-4b-1b-5B
Lerma x Selkirk (Sib) "	II 1893-2b-2b-1b-1T
" " "	II 1893-2b-3b-2b-6B
Frocor x Kentana	II 2463-2b-1b-1b-1T
Frocor x (Yaqui - Kentana)	II 2809-2b-2b-1t-and Reselections
(Galgals - Kenya) x Gabo	II 2830-1b-2b-2b-1T
African x Mayo 48	M 3529-1y-4M-3c-1T and "

These lines are currently in preliminary increase and simultaneously being retested for yielding ability at a number of localities. The best will be released for commercial use depending upon the outcome of this years test.

Table No. 1.

Variety or Cross	P e d i g r e e	Weight per Hectoliter	Hardness Index %
Bola Picota	Regional Check	73.20	40.0
150	" "	76.80	40.0
Mentana 48	Experimental Check	75.90	50.0
Menkemen	Regional Check	75.00	51.2
Frocor	Experimental Check	74.10	40.0
Bonza	Commercial Check	78.60	50.0
Kt-FnxMy 48	947-4b-7b-2b-1B	75.90	31.2
Mq (Manitoba imported)		84.00	30.0
Gold Medal (Imported)			
Kt-BgxFn-U	944-3b-6b-1b-1R	76.35	40.0
Kt-FnxMy 48	947-7b-1b-1b-3R	72.10	42.5
Fn-Th	1255-5p-10r-2r-1R	79.25	46.2
Fn-Th	" 6p-4r-1r-3R	79.70	30.5
Fn-E.95	1446-1b-1b-3b-1B	67.15	47.5
Mt.Res.xCla-Fn	1523-3b-9b-1b-3R	74.55	47.5
"	" -2b-2b-3r-1B	76.55	42.5
Gal-KxN	1560-1b-2b-6r-3B	77.25	37.5
"	" " -4b-1b-1T	77.45	41.0
McM-KtxY50	1571-3b-3b-1r-1B	73.65	40.0
Sa-McMxMy48	1610-4b-2b-3r-2B	79.45	42.5
Kl.Com(N-mt)xMen	1879-7b-4b-2b-1B	70.95	37.0
"	" " " -1b-5B	71.40	41.2
LxSk sib	1983-2b-2b-1b-1T	75.90	43.5
"	" -2b-2b-6B	76.80	40.0
Cheg. 89xKB286	2415-1b-3b-3b-1T	75.00	40.0
Fr-Kt	2463-2b-2b-1T	73.65	32.5
"	" " -1b-1b-1T	75.90	36.5
"	" " -3b-1b-1T	77.45	42.5
Y-Kt sib	2588-4p-7p-5p-3R	79.25	50.0
RiccioxY-Kt	2648-1b-1b-3b-6T	80.80	49.5
"	" " " -1b-3B	80.35	47.5
"	" " " -7b-3T	78.15	45.0
"	" " " -3b-1B	80.35	50.0
Ar-Y48xL	2760-1b-1b-3b-3B	79.00	40.0
"	" " " " -5B	73.20	38.0
Frxy-Kt	2809-2b-2b-1T	76.35	42.5
"	" " -4b-1b-1B	78.60	45.0
"	" " " " -1T	78.15	47.5
"	" " " -3b-2T	77.45	49.0
"	2809-2b-3b-1b-1T	78.35	50.0
Fn-UxL	2821-3b-1b-2b-1T	75.00	45.0
"	" " " " -5T	73.40	47.0
Gal-KxGb	2830-1b-2b-2b-1T	77.70	32.5
Mt ResxSk sib	2943-1b-2b-2b-1B	76.35	46.2
Sp.Wt-GbxL	3046-2b-3b-1b-6B	71.65	50.0
"	" " " -4b-6T	73.20	52.5

Table No. 1 (continued)

Variety or Cross	P e d i g r e e	Weight per Hectoliter	Hardness Index %
Sp. Wt-GbxL	3046-2b-3b-5b-7T	74.10	50.0
"	" " -2b-9b-2B	72.95	52.5
"	" " " -14b-8T	73.20	52.5
AfxMy48	M3529-1y-4m-3c-1T	75.45	35.0
"	" " " -2c-2T	75.45	38.7
"	" " " " -3T	75.60	34.5
Mt ResxMen	4233-1b-1b-9b-1B	73.20	52.5
S-MtxM-Rw	4270-1b-2b-3b-3B	74.55	37.0

Note = The protein determinations were based on actual humidity of sample as were also flour extractions.

F = Fair
G = Good
VG = Very Good

Abbreviations of Parental Varieties

- | | |
|---------------------------|-----------------------|
| 1. Af - Africano | 11. Gb - Gabo |
| 2. Ar - Ardito | 12. K - Kenya |
| 3. BP - Bola Picota | 13. Kl.Com. - Cometa |
| 4. Cla - Centela | 14. Kt - Kentana |
| 5. 150 - Ciento cincuenta | 15. L - Lerma |
| 6. E 95 - Egypt 95 | 16. M - Marroqui |
| 7. Fn - Frontana | 17. Mt - Mentana |
| 8. Fr - Frocor | 18. Mt Res - Mentafen |
| 9. Fto - Fortunato | 19. My - Mayo |
| 10. Gal - Galgalos | 20. McM - McMurachy |

Quality Characteristics of Colombian Wheats.

Grain	% Protein Flour	% Extraction	Absorption H ₂ O 2%	Mixing time Minutes	Volume c.c.	Color /100	Text /100	Grain
12.4	11.6	64.7	60.5	1.50	485	85	75	F
13.7	13.4	71.0	62.5	2.50	835	100	100	VG
11.9	11.2	69.8	56.5	2.00	487	80	90	F
12.3	11.7	70.8	53.5	2.00	537	85	80	F
12.9	12.2	74.6	59.0	2.25	680	80	95	G
11.9	10.2	72.8	55.0	2.25	605	100	100	VG
11.6	10.8	73.0	70.5	2.50	725	90	100	VG
		69.1	63.0	3.00	740	100	100	VG
			60.0	1.50	555	100	100	VG
13.0	12.6	72.0	58.0	1.75	627	95	95	G
12.7	11.9	72.9	67.5	2.50	715	95	100	VG
13.6	12.5	72.9	59.0	2.00	567	85	90	F
11.2	10.2	70.4	60.5	2.25	615	95	100	G
12.7	11.0	68.8	60.0	2.25	657	85	95	G
13.1	12.2	73.6	61.0	2.25	757	95	100	VG
11.0	9.4	71.3	59.5	2.50	637	95	95	G
11.9	10.8	71.7	62.0	2.00	552	90	95	F
12.9	11.7	69.9	62.5	2.50	825	100	100	VG
12.1	11.6	70.0	63.5	3.00	950	100	100	VG
10.9	9.5	75.4	64.5	2.00	562	85	95	F
15.4	---	71.4	67.0	2.25	950	100	100	VG
13.7	12.6	70.0	63.5	1.75	877	100	100	VG
12.3	10.9	70.5	65.0	1.75	830	95	100	VG
11.4	---	66.7	64.0	2.50	767	95	100	VG
10.8	9.9	75.6	60.0	3.25	720	95	100	G
13.2	12.3	70.2	59.0	2.25	640	90	95	F
12.4	11.0	77.1	62.5	2.00	720	95	100	G
12.2	---	72.1	52.0	1.75	510	80	85	F
12.2	---	77.3	56.0	2.25	612	95	95	VG
13.5	12.0	73.1	55.0	2.25	577	85	90	G
11.8	10.7	72.6	54.5	1.50	525	90	90	F
14.5	---	68.0	59.5	2.00	757	90	95	F
11.6	---	70.4	55.5	2.00	555	90	90	F
10.5	10.0	77.2	58.0	1.75	550	90	95	G
12.7	12.2	73.3	67.5	2.00	695	95	100	G
12.4	10.9	74.7	63.5	2.50	670	90	95	F
12.0	10.8	72.4	62.0	2.50	705	90	90	F
11.5	---	72.2	59.5	2.50	630	95	95	F
11.8	---	74.5	64.5	2.50	790	95	100	G
12.0	10.7	74.4	57.5	2.50	597	95	95	F
11.9	10.4	72.7	62.5	2.25	660	90	100	VG
12.6	---	72.4	60.0	2.25	760	90	100	VG
11.4	10.8	77.4	73.5	2.50	755	85	100	G
11.8	10.6	74.5	61.5	2.25	705	95	100	VG
11.8	---	74.0	55.5	2.00	510	80	75	P
12.1	11.3	73.1	56.0	1.75	527	85	85	F

% Protein		% Extraction	Absorption H ₂ O %	Mixing time	Volume c.c.	Color /100	Test /100	Grain
Grain	Flour							
----	10.8	72.7	58.0	2.25	552	95	90	F
12.0	10.6	73.5	56.5	1.75	532	90	90	F
12.0	10.8	74.0	57.0	1.75	525	85	85	P
10.4	9.6	77.4	67.5	4.75	630	100	100	VG
11.2	10.6	75.1	67.0	5.00	600	95	100	VG
11.3	10.3	76.9	64.5	4.75	630	100	100	VG
13.2	----	67.6	65.0	2.25	820	85	100	G
12.5	12.1	76.7	69.0	3.00	725	90	100	G

- 21. Men - Menkemen
- 22. N - Newthatch
- 23. RW - Renown
- 24. S - Supremo
- 25. Sa - Salles
- 26. SK - Selkirk
- 27. SpWt - Spring Wheat
- 28. Th - Thatcher
- 29. General Urquiza
- 30. Y - Yaqui

Discovery of two Hyperparasites, One of Which Has Not
Been Reported, On Uredosori of Puccinia Graminis Tritici

Mario Rosa

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Summary.

In the course of greenhouse studies with Puccinia graminis tritici Erickss. and Henn., two fungi have been found parasitizing the uredosori of the aforementioned rust organism.

The first fungus, which forms a gray-colored colony on the uredosori, has been identified, as Cephalosporium acremonium Sacc. This hyperparasite was previously reported by Hassebrauk on uredosori of Puccinia graminis tritici Erikss. et Henn. (Phytopathologische Zeitschrift, 1936, 1937).

The second fungus, forms colonies of a darker gray color on the uredosori. The walls of the vegetative hyphae are of an olive-gray color, septate, and fairly well ramified. The nonbranched conidiophores are well differentiated, rising at the sides of the vegetative hyphae almost at a right angle. They are continuous and unisepate only in the basal part, with olive-gray walls. They are slightly thinner at the distal end, on which appears a cylindrical cushion, more or less elongated, having over its whole surface little sterigmatic formations on which the conidia are inserted. The conidia are numerous and closely spaced ("radula spores" according to the nomenclature of Mason) with membranes slightly darker than the content, continuous, ellipsoid, and slightly pointed at the base. They measure 6-6.5 x 1.5-2 microns.

Because of these and other morphological and biological characters, this fungus has been identified as Rhinocodiella sp. and probably Rhinocodiella atrovirens Nannf., which, up to now, do not seem to have been reported as parasites of uredosori of Puccinia sp.

Brown Necrosis, a Disease of Wheat Which Sometimes Becomes
Very Destructive Under Conditions of Heavy Rainfall at High
Elevations.

Jacobo Ortega C., N. E. Borlaug, Eduardo Garza F. and Sil-
vestre Espino.

Over the past 30 years it is entirely possible that several

different diseases or abnormalities some of them pathogenic and others of a physiologic or genetic nature have been grouped together under the names of black chaff, melanistic reaction, browning reaction and brown necrosis. There is no doubt but that true "bacterial black chaff" reported by Bamberg is distinct from the conditions reported by Waldron, Mac Fadden, Hart and Allison and herein referred to as brown necrosis.

Over the past 10 years many observations and a limited amount of experimental work has been done in Mexico in an attempt to uncover the true cause of brown necrosis, which often becomes very destructive in wheat that is grown at high elevations under conditions of low temperatures and high relative humidity and heavy rainfall.

Symptoms.

The abnormal condition herein referred to as "brown necrosis" is characterized by a browning of the tissues, and premature dying of the cells of part or all of the exposed portion of the culm and inflorescence of the affected plants. The parts of the plant most commonly affected are the portions of the internodes which are exposed above the leaf sheaths, especially the internodes located immediately above and below the flag leaf. Sometimes the rachis, rachilli and glumes are also affected.

The visible symptoms of this disease normally begin to appear soon after the plant has headed, in the case of susceptible lines which are being grown under environmental conditions favorable to development of the disease. The disease may become progressively worse as the plant nears maturity. In severe cases it results in the death of the culm when the grain is less than half formed. The rate of development and intensity of the browning varies with the variety and also with environmental conditions.

At the onset of the disease tiny strips of tissues running up and down the exposed portion of the internodes begin to turn brown. These streaks, at first very small, coalesce to form more conspicuous streaks and in very susceptible varieties may eventually girdle the culm and result in outright killing of the portion of the culm above the point of girdling.

The cells of the brown areas or strips appear to be dead by the time the color change becomes conspicuous. Killing of the cells in the affected areas progresses from the outside inward. Once the stem has been girdled the process of the translocation ceases, and the damage to the grain will vary directly with the stage of development of the grain when translocation is impaired.

Factors Affecting Severity.

There are a number of factors which appear to affect the

severity of brown necrosis. These are :

- 1.- The variety.
- 2.- Temperature.
- 3.- Relative humidity and precipitation.
- 4.- Light, perhaps both intensity and quality.
- 5.- This phenomenon is often associated with varieties carrying Hope type of stem rust resistance. It, however, also occurs in other wheats, some of which are susceptible to stem rust (Table No. 1).

Under irrigation during the winter months brown necrosis never develops to a point where it is of importance, although in very susceptible varieties and lines small brown or black areas can sometimes be found on the neck and glumes. This is the case whether the susceptible variety is grown near sea level or at 8500 feet. When the susceptible varieties are grown during the summer season, the intensity of the disease is greatest at higher elevations, but at these elevations there is also greater precipitation and higher relative humidity, thus making it difficult to separate the effects of light quality and intensity, and relative humidity or precipitation. In susceptible varieties there is much less development of brown necrosis on the exposed portion of the lowest internode which is partially shaded by neighboring culms and plants, than on the exposed portions of the higher internodes. Repeated observations have also shown that if the leaf sheath is removed from a culm below the area where the culms have been girdled by brown necrosis, the tissues which have been protected by the sheath are found to be entirely normal. In susceptible varieties when small squares of tissue are cut from the leaf sheath the tissues of the culm which are thereby exposed will begin to turn brown within a period of two to four days.

Without exception in the lines which we have studied, all bread wheat varieties which develop a "sun red" anthocyanin pigmentation when grown under irrigation during the dry winter season develop very severe brown necrosis when grown at high elevations during the cool, rainy season. Many lines which do not exhibit "sun red" anthocyanin pigmentation when grown under irrigation are also susceptible to brown necrosis under summer conditions. In some way the phenomenon of brown necrosis seems to be related to the response of the anthocyanin - anthozenthin formation in the plant, and is influenced by light quality and intensity.

When susceptible varieties are planted under environmental conditions conducive to the development of brown necrosis yields are decreased greatly and the grain has low test weight.

Table No. 1.- Varietal Reactions to Brown Necrosis when Grown Under Three Different Environmental Conditions.

Variety	TOLUCA (2675 Mts.)		SONORA (50 Mts)
	Winter ^{1/}	Summer ^{2/}	Winter ^{1/}
Redman	R	VS	R
Selkirk	R	VS	R
Thatcher	VR	R	VR
Newthatch	R	MS	R
Lee	R	MS	VR
Gabo	VR	VR	VR
Frontana	R	MS	R
Lerma 50	VR	VR	R
Lerma Rojo	R	S	R
Kentana 48	R	MS	R
Kenya 324	R	MS	R
Mentana	VR	VR	VR
Maribal 50	R	VS	R
Mariache 50	R	VS	R
Maria Escobar x H44-Marquis (Various Lines)	R	VS	R
Hope	R	VS	R
Gabo 54	R	R	R
Chapingo 53	R	MS	R
Magnif MG	R	S	R

^{1/} Irrigated Winter Crop.

^{2/} Summer crop during rainy season.

REACTIONS :

VR = Very resistant
R = Resistant
MS = Moderately susceptible

S = Susceptible
VS = Very susceptible

Barley Improvement in Colombia.

José A. Sierra, Esteban Rico M. and J. A. Rupert.

The production of barley in Colombia is concentrated largely in the Departments (States) of Cundinamarca, Boyacá and Nariño, between an elevation of 7870 and 9000 feet. The crop is grown on approximately 52,000 hectares, which produce 70,000 tons of grain annually. About 90% of the total production is made up of the varieties Raspa and Pocha, two six-row, "Coast Type" barley varieties belonging to the species Hordeum vulgare L. and Hordeum hexastichon L. The remaining 10 percent is a mixture of other varieties. The commercial plantings are still frequently mixtures of a large number of different phenotypes, which reduces the quality for malting purposes.

Since the improvement program was initiated a large amount of very diverse material has been evaluated for disease reaction, adaptation and agronomic type at the Experimental Stations Tibaitatá, Bonza, and Obonuco. The material which has been evaluated has included selections from the "criollo" ("native") varieties, many introductions from different countries including the entire U.S.D.A. World Barley Collection. The breeding program is designed to combine the adaptation of the criollo varieties with the disease resistance and malting quality of the best introduced material.

The malting and brewing industry of Colombia uses methods and standards similar to those used by the industry in the U. S. A. Consequently the objective of the breeding program is to develop varieties which are similar in quality to the United States varieties.

The results of the improvement program up to the present time, are summarized in Table No. 1. "Funza" the first improved variety to be released for commercial use is a six row type intermediate between the Coast and Manchurian types. This variety was developed as a bulk selection in a farmer's field. The most promising lines currently being tested, which appear to combine high yield, good agronomic type, fair disease resistance and good malting quality, includes the following:

- 1) Funza x Tchechostor 929 II-211
- 2) Funza x Montcalm II-77
- 3) Peatland x Raspa II-15

Table No. 1.- Characteristics of the Most Promising Barleys in the Colombian Program.

Variety or Line	Cross No.	Matur-ity in Days	Yield %	Lodg-ing	Reaction to Diseases					U Nuda Quality
					Helm.	Rhynch	P.A.	P.G.		
Pocha (Test.criollo)		165	100	MS ^{2/}	S	MR ^{2/}	MR	S	MS	Poor
Raspa " "		145	88	S ^{2/}	S	S	MR	S	S	Fair
Funza (Var. Mejorada)		130	156	MS	S	MR	MR	S	S	V.Good
Funza x Tchechostor 929	II-211	125	219	R ^{2/}	MS	R	MR	MR	S	Good
Peatland x Raspa	II-15	140	159	MS	S	R	R	MS	R	Fair
Funza x Montcalm	II-77	140	125	R	R	S	MS	R	R	V.Good
FR1963 ^{1/} x Funza	II-197	135	115	MS	MR	R	MR	MS	R	Good
FR. 63-1 x Kindred	II-204	135	114	MS	MS	R	S	R	R	Good
P.I. 3587 x Funza	II-247	140	135	R	S	S	-	R	R	Poor
Atzel x Funza	II-335	130	140	R	MS	R	-	R	R	Good
FR. 1714 x Erectoi-des 1	II-357	140	125	MS	MS	S	-	R	R	Good
Erectoides 7 x (Surprise x FR1391)	II-757	135	+++	R	R	S	R	R	S	
Ymer x (Surprise x Funza)	II-814	135	++ ^{3/}	R	R	S	MR	R	R	----
PI. 6978 x Funza	II-299	125	+++	S	R	MR	R	R	R	----
Funza x Surprise	II-392	135	++	R	R	MS	R	S	R	----
FR.1894 x Erectoides 6 (Atrada - Atlas) x (Betamil x FR 1391)	II-369	135	++	R	S	MS	R	R	R	----
	II-502	135	+++ ^{3/}	MR	R	R	MS	R	R	----
D.C.Mundial x Odessa	II-157	130	+++	R	S	R	MS	MR	R	----
PI.3625 x Funza	II-266	130	++	R	MR	S	R	-	R	----

^{1/} FR. Rockefeller Foundation

^{2/} R. Resistant
MR. Moderately Resistant
MS. Moderately Susceptible
S. Susceptible

^{3/} ++ = High yielding in preliminary tests

^{3/} +++ = Very high yielding in preliminary tests

Diseases:

P. A. = P. anómala

P. G. = P. graminis

Helm. = Helminthosporium

Rhynch = Rhyncosporium

Sources of Resistance to the Principal Barley Diseases
of Colombia.

Jose Antonio Sierra F. and Rodrigo Arango A.

Most of the important diseases of barley, which have been reported in the principal barley producing areas of the world, are found to a greater or lesser extent in Colombia. The most common diseases of barley are the smuts caused by *Ustilago nuda* (Jens.) Rostr. and *Ustilago hordei* (Pers.) Lagerh. Losses caused by loose smut are considerably greater than the losses from covered smut. A preliminary survey in the Departments (States) of Cundinamarca and Boyacá revealed that the average losses from loose smut was 7.5% and 0.2% respectively, whereas losses from covered smut in the same areas were less than 0.19%.

Other diseases of importance are those caused by *Helminthosporium* spp. (three species), and *Rhynchosporium secalis* (Oud.) J. J. Davis, which is most destructive in areas with extremely high relative humidity. Three rusts, *Puccinia anómala* Rostr., *P. graminis tritici* Erics. & Henn., and less frequently *P. glumarum* are found attacking barley under some conditions. Powdery mildew caused by *Erisiphe graminis* DC. is of economic importance in some areas.

The lines and varieties which appear in Tables I, II, III, IV, V, VI and VII have been selected for their resistance under field conditions over a period of several years at several locations.

Table I.- Sources of Resistance to Helminthosporium spp.,
Rhynchosporium secalis and to Puccinia anómala.

<u>Name</u>
P. I. 8984
P. I. 8985
P. I. 8986
Lion P. I. 923
Ogalitsu x PI 3734 II-697 ^{1/}
DC. 7 N. x Pocha x Research II-755

^{1/}

Line resistant to Puccinia graminis, Ustilago nuda and to Ustilago hordei.

Table II.- Sources of Resistance to Helminthosporium spp.,
and to Rhynchosporium secalis.

<u>Name</u>	<u>P.I. or Cross</u>
Unknown	P.I. 3430
Unknown	P.I. 3210-2
Alba	P.I. 7515
Sprat	P.I. 3331
Arequipa	P.I. 1256
Abyssinian	P.I. 1237
Benghazi	P.I. 2822
Morocco	P.I. 6311
Gold Thorpe	P.I. 2264
Modia	P.I. 2483
Funza x Tchechostor 929	II-211
P.I. 6978 x Funza	II-299
(Atrada x Atlas)	
x	
(Betamil x FR.1391)	II-502

Table III.- Sources of Resistance to Helminthosporium
spp., and to Puccinia anomala.

<u>Name</u>	<u>P. I. No.</u>	<u>Name</u>	<u>P. I. No.</u>
1154		Stellar	P.I. 7274
Unknown	P.I. 3701	Gold	P.I. 1145 ^{1/}
Unknown	P.I. 4976	Gold	P.I. 2141
Unknown	P.I. 6710	Schribaux	P.I. 8323
Or	P.I. 8309	Morocain 017	P.I. 8329
Louhi	P.I. 8342	Morocain 079	P.I. 8334
Erectoides 14	P.I. 3133	Morocain 0139	P.I. 8335
Coast	P.I. 626	Lechtaler	P.I. 6488
Manchuria	P.I. 739	(Funza x H.45)	
Blanqueta B.	P.I. 7483	x	
		(P.I. 3604	
		x	
		Funza)	II-873

^{1/}

Resistant to Erysiphe graminis

Table IV.- Sources of Resistance to Rhynchosporium secalis and to Puccinia anómala.

Name	P. I. No.	Name	P. I. No.
Unknown	P.I. 2543	Cheliff	P.I. 1074
Caveda	P.I. 455	Bonfarik	P.I. 3393-2
Maraini	P.I. 7519	Sea of Azov	P.I. 1440
Perú	P.I. 653	Giza 73	P.I. 9209
Chile Brewing	P.I. 657	Atzel x Funza	II-335

Table V.- Sources of Resistance to Erysiphe graminis.

<u>Name</u>	<u>P.I. No.</u>
Gold	P. I. 2151
Atlas 46	P. I. 7323 <u>2/</u>
Swiss Spring x DF 23	II-39

2/

Line resistant to Puccinia graminis and to Erysiphe graminis.

Table VI.- Sources of Resistance to Ustilago nuda.

Name	P. I. No.
Ogalitsu	P. I. 7152 <u>1/</u>
Valentine	P. I. 7242 <u>2/</u>
Jet	P. I. 2222
Hood 6	P. I. 6270
Peatland	P. I. 2613

1/

Resistant to loose smut.

2/

Resistant to losse and covered smut.

Table VII.- Sources of Resistance to Puccinia graminis.

Name	P.I. or Cross	Name	P.I. or Cross
Lich	P.I. 7610	More x Valentine	II-669 <u>1/</u>
Chevron	P.I. 1111	Valentine x Ogalitsu	II-772 <u>2/</u>
Trebi	P.I. 936	Ogalitsu ₆ x More	II-693 <u>1/</u>
Kindred	P.I. 6969	Funza x (Peatland x FR.1391) x Kindred	II-864
Himalaya	P.I. 254	Jet x Ogalitsu	II-627 <u>1/</u>
Jet	P.I. 967	Funza x Jet	II-387 <u>1/</u>
Bond Ruden2	P.I. 6606	Funza x Kindred	II-389
Hietpas 5 x FR.1697	II-399		

1/

Resistant to loose smut.

2/

Resistant to loose and covered smut.

Sec. 10

Resolutions Passed by the Delegates to the Third International Rust Conference, Mexico City, March 18 - 24.

1. The delegates to the Third International Rust Conference express their deep appreciation to Sr. Don Gilberto Flores Muñoz, Secretary of Agriculture and his representatives the Sub-Secretary, Ing. Jesús Merino Fernández, for the privilege of holding these meetings in Mexico. We appreciate the opportunity of meeting the members of his staff and associating with them at this conference. We are gratified and stimulated by the evidences of his broad comprehension of scientific and practical problems in the improvement of agriculture. We congratulate him on the progress that has been made in agriculture in Mexico and thank him for his contributions to international cooperation.

To our expression of gratitude for his helpfulness and friendly hospitality we add our very best wishes for the future.

2. We appreciate the encouragement and support of the Rockefeller Foundation in helping to make the Third International Rust Conference an outstanding success. Without the help of the Foundation the broad regional representation, which is so essential to the solution of problems such as those of wheat rusts, would have been impossible.

3. We express our gratitude to those countries who contributed so much to the success of the conference by sending many of their outstanding agricultural scientists.
4. We thank the organizing and planning committee for arranging an extraordinarily effective program and for their untiring and efficient efforts in the proceedings.
5. We express our gratitude to the Director General of Agriculture, Ing. Ricardo Acosta V. and those of his staff who courteously and effectively helped the conference in many different ways.
6. We are grateful also to the Director of the Office of Special Studies, Dr. E. J. Wellhausen, and the scientific and clerical staff of the office for helping to solve the manifold personal and official problems in connection with our meeting.
7. The delegates express their gratitude to Mr. Duncan Ritchie for the delightful lunch and entertainment provided under such pleasant surroundings.
8. We express our appreciation to the management of the Reforma Hotel and the Geneve Hotel for helping to provide pleasant and comfortable accommodations and for making us feel at home.
9. We are now in the Hotel San Sebastian, in the quaint city of La Piedad in the beautiful and romantic State of Michoacan. Whether we realize it or not, we can only thank the Office of Special Studies and the Minister of Agriculture for the repast of which we have just partaken, and we are very happy in the Posada San Sebastian, which, in cooperation with the Oficina, so graciously permitted us to get a glimpse of the romance of beautiful Old Mexico.

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